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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD ST., STRAND, LONDON, W.C.2.

VOL. 165—No. 4288 *Registered at the General Post Office as a Newspaper* *LONDON: FRIDAY, APRIL 2, 1948.* PRICE 1s. 6d. POSTAGE {INLAND 2½d. FOREIGN 3d.

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THE STORY OF ATOMIC ENERGY.

X.—FUNDAMENTAL NEW DISCOVERIES AND METHODS.

By Dr. FREDERICK SODDY, F.R.S.*

The Wonderful Year of Radioactivity.

The entirely artificial transmutation, on the single-atom scale, just described for lithium and other light elements, definitely crossed the Rubicon that from the earliest times man had in vain attempted. But it was one only of four great advances that culminated at that time, which has caused 1932 to be dubbed "The Wonderful Year of Radioactivity." The others were, first, the discovery of the long-sought positive electron, or positron, the negative electron from then on being termed the negatron; secondly, the discovery of the neutron, the uncharged unit particle of mass

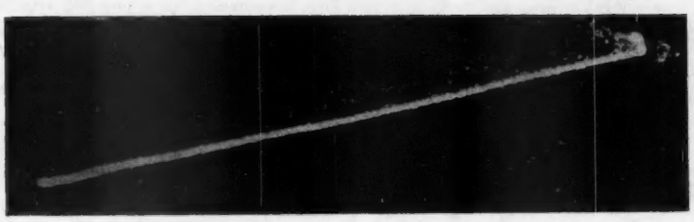


FIG. 76. NITROGEN ATOM DISINTEGRATED BY A NEUTRON.

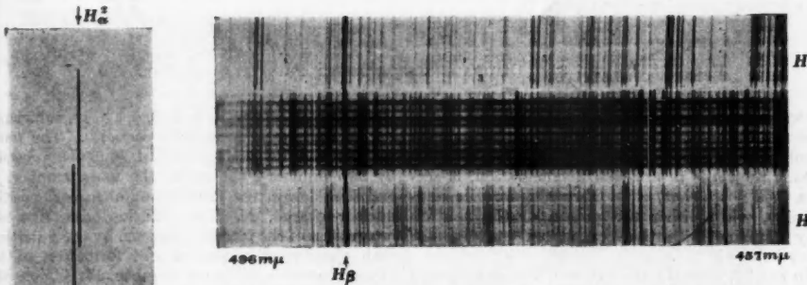


FIG. 78. BAND SPECTRA OF HYDROGEN (UPPER), DEUTERIUM (LOWER) AND THE 50 : 50 MIXTURE (CENTRAL).

FIG. 77. LINE SPECTRUM OF HYDROGEN (LOWER) AND DEUTERIUM (UPPER).

one, and regarded as a neutral nucleus only without external electron; and, lastly, that of the isotope of hydrogen of mass 2, called heavy hydrogen or deuterium, the nucleus of which, called the deuteron, is regarded as the combination of proton and neutron, $p\,n$, and, like ordinary hydrogen, has in the atom one external electron. In the following year, 1933, another discovery, in some ways, to the original pioneers at least, the most interesting of all, was made, namely, artificial radioactivity. Most of these were due to the single-atom methods of detection already described, but for which they could not have been made.

The Electron-Pair.

The positron was first observed by Carl Anderson at the California Institute of Technology, as the "electron-pair," in Wilson tracks of cosmical rays taken in a magnetic field to deflect the charged particles. These showed a precisely similar pair of tracks, curving away from a common origin equally in opposite directions, due to precisely similar electrons carrying opposite charges. After similar results had been obtained by Blackett and Occhialini in England, Anderson brought them down to earth and showed that the production of these electron-pairs is a normal consequence of the passage of γ-rays of sufficient energy through heavy elements. For any γ-photon, of energy definitely greater than 1 M.e.v. as the "threshold" energy, this production increases as the square of the atomic number, or nuclear charge, of the element traversed. The positron, like the neutron, is an elusive particle as it readily combines with either negatrons or nuclei and so, even more than the negatron, is only capable of an ephemeral existence in the free state.

The Disintegration of the Photon.

Its combination with the negatron is regarded as the reverse of the process by which it was discovered, the change,

$$\gamma\text{-photon} = e^+ + e^-,$$

proceeding either way according to the energy conditions. The energy equivalent of the mass of the electron is 0·5 M.e.v., and the conservation of momentum requires that it be produced in pairs, which accounts for the threshold energy of the γ-rays producing them being 1 M.e.v. This process is often called the materialisation of the photon, though it should be called the electricalisation of it. If correct, it is a veritable annihilation of mass into, and conversely, its formation from, energy, and so far as these phenomena are concerned, seems well-established.

Maybe on account of the muddle already gone into between quanta of Action and quants of energy or momentum, the contemporary world of physical science appears to have been somewhat tardy in appreciating the possibly fundamental and revolutionary implications of this reversible relation between the high-energy photon and the electron-pair. But to the onlooker, who, proverbially, sees most of the game, it suggests one of the most revealing advances yet made as to the nature of light and the relations between electricity, matter and energy. For from what has already been said as to the nature of the quantum of Action rendering the actual combination or fusion of positive and negative electric charges impossible, it seems natural now to regard the photon as akin to a binary star, consisting of the two equal and opposite electronic charges revolving round their common centre of gravity. This, again, accounts for the wave-nature of the particle, also mentioned, since a system constituted in this way would be surrounded by an electromagnetic wave and carry it with it in its movements wherever it went. It may be that this accounts for the wave having a particle aspect, rather than that of a spherical spreading pulse.

An important consequence of this disintegration of high-energy photons by matter is that the penetrating power of γ-rays for the heavy elements, which at first increases with the energy of the rays, reaches a maximum at about 3 M.e.v. energy, which is about the highest for the γ-rays of the natural radio-elements, and then decreases. For lead, most of the absorption of γ-rays of 10 M.e.v. energy is ascribed to the above process. Many of the early conclusions with regard to the nature of the cosmical radiation were entirely vitiated by this subsequently discovered effect.

The Neutron.

The neutron was first detected by Boethe and Becker in 1930, in a very curious and unexpected way. They found that the α-rays of polonium, impinging on lithium, boron and, notably, beryllium, produced what they took to be a γ-radiation of then unparalleled penetrating power, requiring an inch of lead to reduce it to half-value. But M. and Mme. Joliot, son-in-law and daughter of M. and Mme. Curie, repeating this, found the supposed radiation to be very easily absorbed by hydrogen-rich substances such as paraffin wax and water, and to produce, in these, fast radiant protons of range 26 cm. in air and 4·3 M.e.v. energy. Then in 1932, J., now Sir James, Chadwick found that they put into energetic recoil the nuclei of light elements, enabling them to be made visible by their Wilson tracks, and he it was that first drew the correct conclusion that the effects were due not to photons, but to the ejection of high-speed neutrons. The point about their discovery was that polonium gives exclusively an α-radiation of quite low velocity and range, and that, if any other source had been employed, the minute effect would probably have been swamped by the secondary effects of more powerful rays, and so have remained undiscovered. Fig. 76 is reproduced from a Wilson-chamber photograph by Professor P. I. Dee. The tracks produced by neutrons start "out of the blue," because the neutron itself only gives a track by striking the nucleus of an atom in its path and causing it to ionise the gas by its recoil. In this photograph, the nitrogen nucleus struck by the invisible neutron has been disintegrated into a boron atom giving the short track, and a helium atom or α-particle giving the long track; in the notation explained later in this Part, ${}^{14}_{7}\mathrm{N}\ (n\,;\,\alpha)\ {}^{10}_{5}\mathrm{B}$.

Twelve years earlier, 1920, Rutherford had prophesied the possibility of the existence both of the neutron and deuteron, and had forecast their probable properties with remarkable accuracy. He envisaged the former as a nucleus only, of mass one and charge zero, able, because uncharged, to move freely through matter and the external electronic systems of atoms, and therefore permeating the walls of sealed vessels, but readily either combining with the nuclei of other elements or disrupting them, or of itself being disintegrated by their intense field, ejecting a proton or negatron, or both. All of this has proved to be not only true, but the key to mass transmutation.

There is, however, one very important difference. Rutherford envisaged the neutron, naturally, as the compound of the proton and negative electron. To-day, it is regarded as the elementary protyle, or unit of all matter, and the proton as its compound with the positron. This is because the mass of the neutron, 1·009, is greater than that of the proton, 1·008 plus that of the electron, 0·0005, whereas on the former view it should be less, since if it were constituted this way, energy would be released and mass lost.

The New Nucleus.

This, and the discovery of the positron, has removed the greatest anomaly about the nuclear atom. Before, to account for the expulsion of β-rays from the radio-elements, one had to suppose that negatrons as well as protons existed in the nucleus. Indeed, to account for the mass, M, clearly there must be as many protons M, as the atomic mass, and since the atomic number, N, is the positive charge, as many negatrons as the mass number minus the atomic number, i.e., M — N. This is, for the heavier elements, rather more negatrons than the atomic number N, or net positive charge. In view of the minuteness and stability of the nucleus such a view was never even plausible.

* We have arranged with Dr. Soddy to publish his new book, *The Story of Atomic Energy*, in the form of a series of articles which are appearing at fortnightly intervals approximately. Dr. Soddy, however, retains the copyright; therefore no extract may be made from these articles without his permission.—ED. E.

Now, it is not necessary to suppose the nucleus contains any negatrons at all. It can be, and is, regarded as compounded of as many protons as the atomic number, N, and as many neutrons as, with the protons, will make the atomic weight or mass-number, M, that is the difference between the two numbers, M—N. For the heavier elements, in proportion to their heaviness, there are more neutrons than protons. Anticipating, this is why nuclear fission, of arithmetical necessity, by releasing free neutrons, made mass-transmutation artificially practicable though the ordinary disintegration is still only possible on the single-atom scale.

However, it remains doubtful whether the β-rays referred to are correctly accounted for on this view. They can be, by supposing that a γ-photon starts to be ejected by the nucleus but, before leaving, suffers immediate transformation into the negatron, which is ejected as the β-particle, and the positron which combines with a neutron in the nucleus, producing a proton. But an alternative view, of the theorist Gamow, is that a negative proton may exist in the nucleus, the counterpart of the one known, just as the positron is of the much longer known negatron. This has some advantages, but such a particle has not yet been discovered. The reader must be forbearing if these extremely simple ideas appear over-laboured, but, if they are now properly grasped, it will very much simplify the discussion of present-day views of the nucleus to be elaborated later.

Heavy Hydrogen.

Coming next to the discovery of heavy hydrogen, we are back again to the only original source of information as to the mass of the nucleus, namely, the isotopes. But here we have to do with an isotope entirely different in its physico-chemical and physical character from any other, in that it departs in properties sufficiently from ordinary hydrogen to be separated pure comparatively easily. It is, as Rutherford envisaged, a nucleus compounded of a proton and neutron, pn, with a single negatron outside, like the ordinary hydrogen atom. Its discovery also is curious and, to the student, rather reminiscent of the way argon was discovered. At first there was almost complete agreement between the chemical and mass-spectrographic values for the ratio of atomic weights of hydrogen and oxygen, but this was deceitful. Argon was discovered through a discrepancy in the atomic weight of nitrogen, as determined by its density, that for atmospheric nitrogen being greater than that from nitrogen compounds. Heavy hydrogen was indicated by a spurious agreement between the chemical and physical methods of determining the atomic weight of hydrogen in terms of that of oxygen.

Band Spectra of Isotopes.

It should have been said that the identity of character of isotopes (with the single exception of heavy hydrogen) extends to their line spectra, which are atomic spectra, to so close an approximation that, by ordinary methods, no difference can be detected. But this is not the case at all for band spectra, which are molecular spectra, as here the mass of the constituent atoms enters into the quantities that determine the wavelengths. Before the mass spectrograph had attained its present perfection, band-spectra had revealed the presence of minute proportions of heavier isotopes in such common elements as carbon, nitrogen, and oxygen, then quite beyond the power of the mass spectrograph to resolve. As oxygen was found to contain as much as one part in 500 of an isotope of mass number 18, and one in 2,500 of mass-number 17, in addition to the main isotope of mass number 16, it was clear that hydrogen must also contain about one part in 4,500 of an isotope of mass 2, to cause the close agreement referred to between the chemical and physical mass ratios. This was predicted by Birge and Menzel, and almost at once verified by H. M. Urey, in America, in 1932, who found that, in the electrolysis of water, the heavy isotope is concentrated in the part of it not electrolysed. Up to the outbreak of the second World War, this was the method by which pure "heavy water," D_2O, was made commercially on a large scale for scientific investigations, in the hydro-electric installations in Norway.

Properties of Heavy Water.

Heavy water freezes 3·8 deg. C. above the freezing point of ordinary water and boils 1·2 deg. C. above the boiling point, and its maximum density is over 10 per cent. greater, the maximum density being at 11·5 deg. C. instead of 4 deg. C. But most interesting is its line spectrum, as it is shifted to the violet side of that of ordinary hydrogen to a small but quite easily detectable amount. This shift, moreover, is exactly in accord with a very simple calculation from Bohr's theory of the hydrogen spectrum, by taking into account the shift of the centre of gravity of the atom, round which the electron revolves. Its band spectrum is completely different from that of ordinary hydrogen, and the 50 per cent. mixture of each shows not only the two spectra of the two pure substances D—D and H—H, but a third equally strong, corresponding to the molecule, D—H. It was this striking difference for chlorine, the first of the common elements to be resolved by the mass spectrograph, that first drew attention to band spectra in this connection. The most valuable property of the deuteron is as a bombarding agent to produce transmutations. As an atomic projectile in artificial disintegration, it acts as a shell not a shot, often disrupting into its components, when either the proton or the neutron may combine with the bombarded nucleus, the other being ejected.

In Fig. 77, page 313, the red, or α, line for hydrogen is shown in juxtaposition with that for deuterium. The latter is shifted to the violet side by 1·78 Å, exactly that calculated from Bohr's theory as due to the shift of the common centre of gravity of nucleus and electron. The two lines are easily resolvable in an ordinary spectroscope. Fig. 78, page 313, is of the band-spectra due to the diatomic molecule, H_2. The upper spectrum is that of ordinary hydrogen and the lower that of pure deuterium; the middle spectrum of the equal mixture has in addition to both these spectra a third spectrum corresponding with H — D, the molecule comprising an atom of each. The photographs from which Figs. 77 and 78 have been reproduced were taken by G. Hertz, a German investigator who pioneered in the application of diffusion to the separation of gaseous isotopes and greatly improved the known methods for this purpose.

Hydrogen and Zero-Point Energy.

This great difference of physical and chemical character of the hydrogen isotopes is not, however, to be attributed entirely to the relative difference of masses, 2 to 1, being much greater than in any other case. Rather it is, as Polyani pointed out, a result from the quantum theory, making the initial assumption that the chemical character of the two atoms is identical. It is due to what is called the zero-point energy, in this case of a compound in contrast to that of the free atom, which is its vibrational energy at the Absolute Zero of temperature. This is the greater both as the forces of attraction in the molecule which hold the atoms together increase and as the masses of the latter diminish. For both these factors increase the frequency of this vibration and therefore, the magnitude of the energy quant $h\nu$, corresponding with the quantum of Action. So that it comes about, first, that the zero point energy differences increase not as the relative mass-ratio of two isotopes, but approximately as the square of this, which makes the hydrogen isotopes the only ones for which this effect is large; and secondly, in the question of separating isotopes by their consequent minute differences of physico-chemical behaviour, those compounds will be the easiest to separate of which the heats of formation from the elements are the greatest—for example, for hydrogen, the fluoride or chloride, more easily than the iodide. This by now has led to much better methods of separating the isotopes of hydrogen than those first commercially practised.

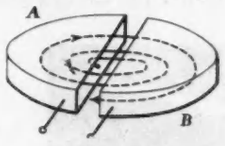


Fig. 79.

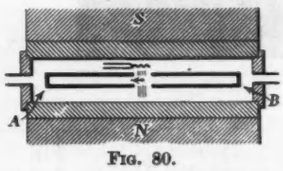


Fig. 80.

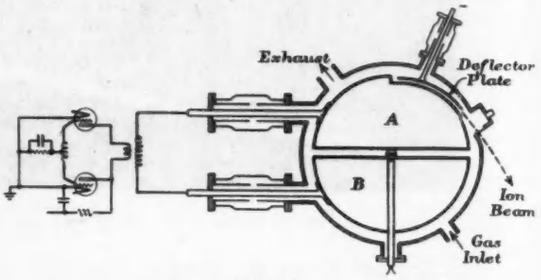


Fig. 81.

Figs. 79, 80 and 81. Diagrams Illustrating Principle of Cyclotron.

Transmutational Notation.

It is convenient, before proceeding farther, to explain the simple shorthand symbolism by which nuclear changes are now expressed. Up to the recognition of nuclear fission, only a year or two before the outbreak of the Second World War, all nuclear changes were of the same type, namely, the transformation, by a radiant charged projectile or neutron projectile, of one nucleus into another, with or without the ejection of another ray or particle. This is expressed by a four-fold specification, in which the letters p, n, d, α, β, γ, e^+, e^-, sufficiently indicate the rays or radiant particles. The nuclei are denoted by their chemical symbols, preceded by two numbers, the upper the mass number, M, and the lower the atomic number, or positive nuclear charge, N. Thus Rutherford's first disintegration of the nitrogen nucleus, by the α-particle, with ejection of a proton and formation of the oxygen nucleus of mass number 17, is, on this symbolism, $^{14}_{7}N\ (\alpha\,;\,p)\ ^{17}_{8}O$, in which the bracket placed between the two nuclei contains, first, the disintegrating particle and, second, the ejected particle, if any.

The whole point is that both the charges and the masses must equate, as between the two reacting particles on the left and the two product particles on the right. In the case given, $14 + 4 = 17 + 1$, for the masses and $7 + 2 = 8 + 1$ for the positive charges. In this symbolism the negatron of course counts as -1, and the neutron as 0 a zero charge. By 1945, over 400 primary, and 200 of the secondary changes, about to be considered, were known to occur, which shows the need for some such shorthand. The original discovery of the neutron, already considered, on this method of representation, is, for beryllium $^{9}_{4}Be\ (\alpha\,;n)\ ^{12}_{6}C$; that is to say, the nucleus resulting must be that of ordinary carbon, if the law of conservation of both mass and charge is to be satisfied. For, $9 + 4 = 12 + 1$, and $4 + 2 = 6 + 0$. These laws of conservation of both the mass and the charge make the interpretation of transmutational changes extraordinarily simple. That is where, by correct chemistry, what physicists now term nuclear physics had got to soon after 1932.

This has nothing whatever to do with any special theory of the atom, nuclear or other. It was the Displacement Law that first showed that the electric charge, as well as mass, is conserved in atomic change, while the Einstein fusion of the laws of conservation of mass and energy is also totally independent of theories of matter. Knowing the exact isotopic masses, the last enables the energy released or absorbed in any such change to be written down at once. Thus this four-fold symbolism is, perhaps, the most concentrated and informative ever devised.

THE STORY OF ATOMIC ENERGY.

FIG. 82. 220-TON CYCLOTRON AT BERKELEY UNIVERSITY, CALIFORNIA; SIDE FROM WHICH BEAM EMERGES.

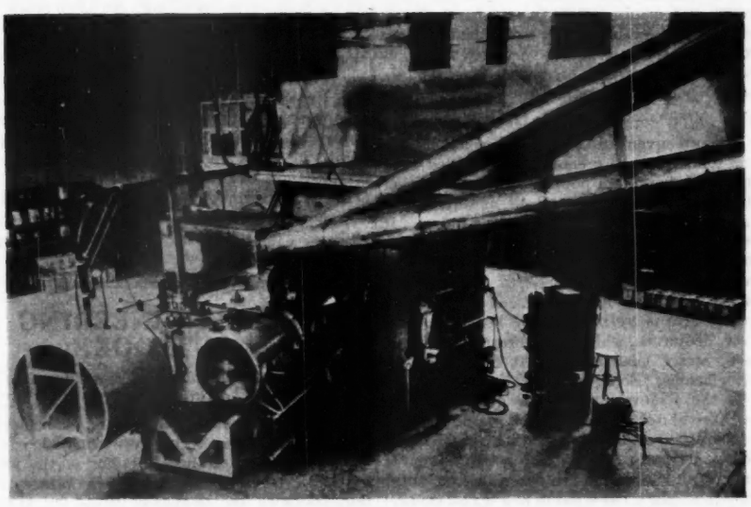


FIG. 83. 220-TON CYCLOTRON AT BERKELEY UNIVERSITY; SIDE TO WHICH RADIO POWER IS SUPPLIED.

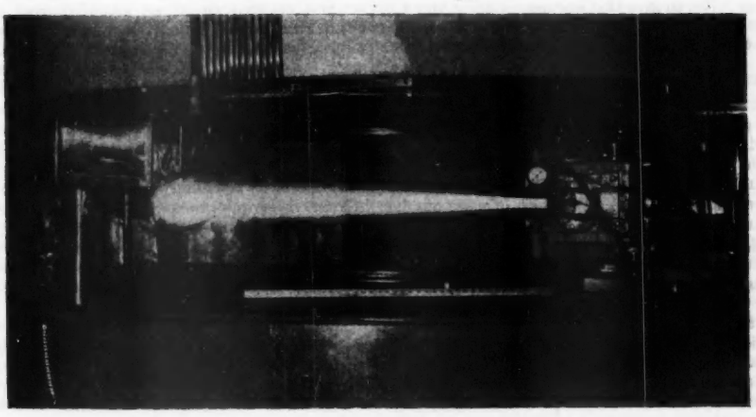


FIG. 84. BEAM OF 16 M.E.V. DEUTERONS, 5 FT. IN LENGTH, EMERGING FROM CYCLOTRON.

ARTIFICIAL RADIOACTIVITY.

Turning now to the discovery of artificial radioactivity in 1933-4, one reason why it was of the greatest interest, at least to one of the original pioneers, was that it was achieved by her daughter and son-in-law. Mme Curie had the satisfaction, a few months before her death, of handing on the torch she had lit to members of her own family. The subject she had elevated from a curiosity to a Colossus, a quarter of a century later, even as she died, was about to enter on a new and fruitful lease of life.

M. and Mme Joliot, in their study of the Boethe effect described, found the counter continuing to register impulses after the polonium originally exciting them was removed. These impulses died away exactly as for an ephemeral radio-element with the half-period of about 3 minutes. They found that the aluminium window through which the polonium α-rays had passed had been rendered radioactive by the neutrons produced, and that boron and magnesium gave similar effects with different half-periods, 11 and 2·5 minutes, respectively. The reactions for the first two were

$$^{27}_{13}\mathrm{Al}\ (\alpha\,;n)\ ^{30}_{15}\mathrm{P}^{*}\longrightarrow{}^{30}_{14}\mathrm{Si}+e^{+}$$
$$^{10}_{5}\mathrm{B}\ (\alpha\,;n)\ ^{13}_{7}\mathrm{N}^{*}\longrightarrow{}^{13}_{6}\mathrm{C}+e^{+}$$

in which the asterisk denotes that the nuclei first produced are radioactive and undergo the further secondary changes indicated by the arrows, the final products being stable known isotopes of silicon and carbon. For magnesium, all three isotopes, of mass numbers 24, 25 and 26, participate and all differently, producing neutrons, protons, positrons and negatrons, the final products being stable known isotopes of aluminium and silicon, in the combined changes,

$$^{24}_{12}\mathrm{Mg}\ (\alpha\,;n)\ ^{27}_{14}\mathrm{Si}^{*}\longrightarrow{}^{27}_{13}\mathrm{Al}+e^{+}.$$
$$^{25}_{12}\mathrm{Mg}\ (\alpha\,;p)\ ^{28}_{13}\mathrm{Al}^{*}\longrightarrow{}^{28}_{14}\mathrm{Si}+e^{-}.$$
$$^{26}_{12}\mathrm{Mg}\ (\alpha\,;p)\ ^{29}_{13}\mathrm{Al}^{*}\longrightarrow{}^{29}_{14}\mathrm{Si}+e^{-}.$$

Moreover, it was easy to identify as such the ephemeral radio-phosphorus and radio-nitrogen produced in the first two by the ordinary chemical methods employed in radio-chemistry. These first results show the wealth of new data that resulted, and they will later serve to illustrate the simple general principles now known to govern these nuclear reactions.

HIGH-TENSION ELECTRICAL ENGINEERING.

But first something must be said of the great advances made in high-tension technique, which were soon to leave far behind the hitherto unchallenged energy-levels applying to the naturally radioactive elements, for which, as we have seen, at the maximum are normally not above 4 and 8 M.e.v. for the singly- and doubly-charged particles, respectively. Very great improvements were effected both in the old type of electrostatic methods for generating high voltages, by what used to be known as frictional and induction machines, as well as in the commercially used high-voltage alternating-current transformers. However, here it may be said that, though the production of artificial lightning is not the object, it is a contingency very difficult to avoid. So that the necessary spaciousness of the building housing the generator, to prevent the discharge striking the sides or roof, or to earth, in practice limits this type of machine severely, to potentials not much above one or two million volts. Though useful in certain researches, for sheer power they are now quite eclipsed by the cyclotron.

THE CYCLOTRON.

This is a most ingenious machine, perfected by E. O. Lawrence, of Berkeley University, California, to which the only real limitation, apart from the cost, of the energies reached seems to be the relativity increase of mass with speed of the positive ions it generates, and this does not seem to be insuperable. It generates these high-speed positive ions directly *ab initio* inside a vacuous chamber, of the form of a shallow cylindrical box between the poles of an enormous electromagnet. Though only fully realised in the latest to be designed, the machine can begin with high-frequency alternating currents of the Tesla type at voltages at which the other types of machine become impracticable, and then multiply this potential up to any desired

extent. A decade ago it could produce protons and deuterons of 6 M.e.v. energy. This was increased to 16 in the next to be built, and was confidently expected to reach 100 in one being built before the war, for which the Rockefeller Institute had made a grant of a million dollars, the electromagnet of which weighs 5,000 tons. But this was commandeered for the war work on the atomic bomb, and, so far as is known to the writer, the machine has not yet been finished. Fig. 79, page 314, shows a shallow circular box cut in two halves, termed the "dees," inside which the positive ions generated pursue a spiral path from near the centre to the periphery, being accelerated each time they cross the gap between the dees. Fig. 80 shows the dees, lettered A and B, between the poles of the electromagnet. Fig. 81 is a view in plan, the axis of the polepieces being vertical, showing the high-tension leads to the dees A and B, and the highly negatively charged deflector plate to bring out the ion-beam through a thin window of mica. Figs. 79, 80 and 81 have been taken from *Electron and Nuclear Physics*, by J. Barton Hoag, Chapman and Hall, Limited, 1938.

The cyclotron is essentially an enormous electromagnet with a narrow gap between large flat circular poles disposed horizontally one above the other, in which is situated the vacuous chamber. Inside the latter near the centre, positive ions of the sort desired are generated. If the magnet alone operated, their trajectory would be coiled into a small circle in the horizontal plane. But at each half revolution they pass between highly charged conductors connected to the opposite poles of the high-frequency alternating-voltage generator, which increases their velocity, always in the same direction, so that they spiral outwards to the periphery at ever-increasing speed. This is done by synchronising the frequency of the alternations so that the polarity at the gaps reverses exactly at every half-revolution of the ions, and is possible because, relativity considerations apart, the time of revolution is constant. The increasing speed is exactly compensated for by the increasing length of path as the ions spiral outwards. When they reach the periphery they are electrostatically deflected through a very thin window and pass out into the outer air. The 16 M.e.v. deuterons attain a speed of 25,000 miles a second, nearly one-seventh of the speed of light, and travel 5 ft. through the atmosphere as a glowing beam. As explained, for helium ions, or α-particles, the energy is double this. By these means energy levels have been attained artificially, so greatly exceeding what is possible with the natural radio-elements, that the latter now appear relatively feeble. In consequence, protons, neutrons, deuterons and α-particles in much greater abundance and of much greater power than before have recently become available for scientific investigation.

Figs. 82 and 83, on page 315, show the 220-ton cyclotron, with 60-in. diameter pole-pieces, at Berkeley University, California. Fig. 82 shows the side from which the beam emerges. The physicist in this illustration working the controls, Dr. H. J. Walke, of Liverpool University, was killed by an electric shock while working there on December 21, 1939, aged 28 years. On the platform, to the left, is the radio-power supply house, made of aluminium. Fig. 83 shows the side on which the radio-power supply enters through the two converging tubes. The extension in the left corner is a safety shield to keep passers-by away from the deflector plate high-voltage supply. Professor Milton White, of Princetown University, is standing at the corner diagonal to that where Dr. Walke was standing in Fig. 82. Fig. 84 shows a beam of 16 M.e.v. deuterons, travelling at 25,000 miles per second, emerging and penetrating nearly 5 ft. of the atmosphere. The photographs from which Figs. 82, 83 and 84 have been reproduced were taken and supplied by Dr. Donald Cooksey, Assistant Director of the William H. Crocker Radiation Laboratory.

To one who has grown up with this subject, Fig. 84 epitomises vividly the progress made in this subject during the present century, and may be contrasted with Figs. 41 and 42 of Part V (see Engineering, December 26, 1947, page 603), illustrating the penetrating power of the natural α-rays. Then it was amazing enough that helium atoms could traverse without serious deflection a few centimetres of air at atmospheric pressure, or a few ten-thousandths of an inch of glass, whereas in Fig. 84 we see atoms of matter artificially accelerated by potentials of many millions of volts traversing over a metre of air at atmospheric pressure and revealing themselves by the characteristic glow previously confined to the Geissler-tube type of discharge in highly rarefied gases. Somewhat later, a similar change of scale has been effected for the penetrating power of the β-ray, or radiant negatron, by means of a similar machine, known as the Betatron, of which space precludes further mention here.

Transmutations by the Cyclotron.

When deuteron meets deuteron, as by bombarding a target containing heavy hydrogen with deuterons, even at 20 kV, enormous numbers of protons result, of 14-cm. range, the nucleus formed being "tritium," an isotope of hydrogen of mass 3, for which a costly but fruitless search in heavy water was once made. In this, 13,000 tons of water were electrolysed and 43·3 kilograms of heavy water of 99 per cent. purity were separated, but it contained no "tritium," ${}^{3}_{1}\mathrm{H}$, which is now known to be radioactive, with a half-period of some 30 years, giving feeble β-rays, and changing into the isobaric helium isotope, ${}^{3}_{2}\mathrm{He}$.

With 100-kV deuterons, in addition to the foregoing, another reaction occurs. Neutrons in very high yield result together with the isobaric helium isotope of mass 3. With 1 M.e.v. deuterons, one neutron results for every few thousand deuterons, and the absence of γ-rays makes it a preferable as well as a much more abundant source of neutrons to use than radium. The existence of this helium isotope of mass, 3, to the extent of only one ten-millionth in ordinary atmospheric helium, and only one-twelfth as much in helium from natural oil-gas, has recently been established by using the cyclotron itself for this purpose, as this is very very far below the utmost range of the best mass-spectrograph. The nuclear neutrons discussed are symbolised by

(1) ${}^{2}_{1}\mathrm{H}(d\,;p){}^{3}_{1}\mathrm{H}^{*}\longrightarrow{}^{3}_{2}\mathrm{He}+e-$; (2) ${}^{2}_{1}\mathrm{H}(d\,;n){}^{3}_{2}\mathrm{He}$.

The most convenient source of neutrons for ordinary folk, if wealthy enough, is a sealed tube containing fine beryllium powder mixed with either some 100 milligrams of radium itself, as sulphate, or charged as required with the equivalent radon. It gives about 20 million neutrons per second per gram of radium, of energy some 10 M.e.v., so that it takes some 8,000 α-particles to produce one neutron—a relatively high yield. A much more abundant source is by bombarding beryllium with 0·9 M.e.v. deuterons, which transform it to a stable isotope of boron, mass number 10, by ejection of 9 M.e.v. neutrons, ${}^{9}_{4}\mathrm{Be}(d\,;n){}^{10}_{5}\mathrm{B}$.

One of the achievements of the cyclotron is to produce a rival to radium, namely radio-sodium, by bombarding common salt with high-energy deuterons. Its half-period is 15·5 hours. It gives relatively weak β-rays, but these are accompanied by a very powerful γ-radiation of 5·5 M.e.v. energy, much more energetic than those from radium. It is better got, however, by using the cyclotron to yield neutrons as described, which unite with ordinary sodium ${}^{23}_{11}\mathrm{Na}$, to give this isotope, which is one unit heavier, ${}^{24}_{11}\mathrm{Na}$. In this way preparations having the activity of 30 grams of radium have been made.

Natural Radio-Elements Made Artificially.

But perhaps the greatest triumph of the cyclotron is the production of the radioactive isotopes, Radium E and F, the latter being Mme. Curie's polonium, and the former its immediate parent in the disintegration series. The Displacement Law showed the former to be an isotope of bismuth of mass number 210, instead of 209, as for ordinary inactive bismuth, giving, by a β-ray change of half period 5 days, polonium in the next succeeding place in the sulphur family, formerly vacant, which then passes by an α-ray change, half-period, 140 days, into the final stable lead isotope of mass number 206. These historic originals have been artificially made by bombarding bismuth with deuterons of 5 M.e.v., the neutron of the deuteron sticking to the bismuth, forming radium E, and the proton being ejected. For higher energy deuterons, in addition to the foregoing reaction, the proton sticks to the bismuth forming polonium directly, and the neutron escapes. These artificial radioactive isotopes display complete identity of character with the long known natural ones, and they show how well and truly the riddle of radioactivity has been read.

The Neutron as Transmuting Agent.

Lastly and most important of all, as first recognised by Fermi, is the dual role the neutron can play. As generated, they have usually kinetic energy fully equal to other radiant projectiles, and they disintegrate nuclei by collision with them in much the same way. But as M. and Mme. Joliot found, before they were recognised as such, they are what is now called "hydrogen-sensitive." Because of the identity of mass with the hydrogen atom, their velocity is far more rapidly lost by collisions with hydrogen than with any other atom. By surrounding their sources with paraffin wax or water, their energy is quickly reduced to that of the ordinary gas molecules at room temperature, 0·04 e.v., and even less at lowered temperatures, and as such they are known as "thermal neutrons." Then they show what nothing else does, ability simply to unite with even the heaviest and most highly charged nuclei, against which a positively-charged particle, however energetic, cannot make effective headway.

Fermi showed that 47 out of 68 elements of all atomic weights which he subjected to slow neutrons were rendered radioactive, emitting β-rays, so that the slow neutron may be considered a nearly universal transmuter. In consequence of this, absorption is often abnormally great for thermal neutrons, especially with boron, cadmium, silver and gadolinium, the last being one of the rare-earth elements, which are therefore used as neutron shields, allowing the fast neutrons to pass but stopping the thermal neutrons completely.

Also the radioactivity they produce in these elements is used as a means of detecting and measuring neutrons. Some of them show selective absorption for thermal neutrons of particular "temperature" ranges. For cadmium the abnormally great absorption does not begin until the energy is reduced below 25 times the energy of neutrons at room temperature, and it reaches its maximum at some three or four times this temperature. All of these facts enter into and have made it possible to regulate and control the artificial liberation of atomic energy.

THE ENGINEERING OUTLOOK.

XIV.—General and Constructional Engineering.

This article, as is customary, concludes the present "Engineering Outlook" with a brief review of the activities of those sections of the industry not surveyed in previous articles. Where production statistics are available, these are shown in Table I, opposite. It will be seen that, though many sections are included, the list is by no means exhaustive; for example, among the important sections omitted are those manufacturing cranes, hoists and other lifting machinery; conveyers, telphers and transporters; cement-making machinery; food-processing machinery; grain-milling machinery; gas and chemical machinery; scientific instruments; excavating machinery; and several others. Some indication of the relative importance of these sections can be obtained from their export performance, but, in general, information is somewhat scanty. Machinery sections already covered accounted for approximately 52 per cent. of the total machinery exports during 1947. Employment figures for the machinery industry as a whole are given by the Ministry of Labour under the heading "General Engineering, Engineers, Iron and Steel Founding, etc."

The need for more comprehensive information has been stressed in previous articles: clearly, no efficient planning of engineering activity can take place without it. There are, however, serious difficulties in analysing the distribution of labour and in obtaining the necessary production returns from firms whose output includes a wide range of products. One large organisation of this type pro-

duces, *inter alia*, marine-engineering products, cement-making machinery, machine tools, precision instruments, chemical plant and conveying machinery. The proportion of labour employed on each activity is difficult to assess, often overlaps, and is liable to vary from week to week. The collation of relevant data from the very large number of jobbing engineering firms, often small, manufacturing parts and components to the specifications of machine builders, presents even greater difficulties; but, without such information, it is exceedingly difficult to assess the engineering potential of the country.

The employment figures given in Table II, below, show that general engineering succeeded in expanding its labour strength by 45,600 during the past year. The contraction, which began in 1945, from the war-time peak of nearly 1½ million, was checked in mid-1946, when 902,400 were employed. By the end of the year, employment had risen to 938,800, and by the end of 1947, to 983,200. One significant feature is the arrest of the decline in the number of women employed. The lowest level was reached in June, 1947, with 169,400; this was maintained in August and began to rise in September. At the end of the year, 173,400 women were employed, amounting to about 18 per cent. of the total labour. This increase in employment suggests a high level of activity, which is borne out by the production figures given in Table I.

TABLE I.—UNITED KINGDOM: OUTPUT OF CERTAIN INDUSTRIES CLASSIFIED AS "GENERAL ENGINEERING." (Quarterly averages or calendar quarters.)

Product.	4th Qr., 1946.	1st Qr., 1947.	2nd Qr., 1947.	3rd Qr., 1947.	4th Qr., 1947.	Deliveries in 4th Qr., 1947, as Percentage of 4th Qr., 1946.
By Value (£1,000).						
Internal-combustion engines*	3,930	3,923	4,434	5,145	6,520†	166
Steam engines	139	143	142	133	159	114
Shell boilers	1,072	875	1,098	1,335	1,682	157
Steam-raising plant accessories	1,406	1,120	1,581	1,818	2,516	179
Industrial valves	1,747	1,965	2,252	2,495	2,769	159
Pumps and pumping equipment	2,063	2,186	2,724	2,690	2,817	135
Ball and roller bearings	—	—	3,538	3,460	3,976†	—
Welding machinery	414	369	489	495	606	146
Woodworking machinery	3,292	3,080	4,341	4,335	3,500†	106
Boot and shoe machinery	—	480†	520†	530†	550†	—
Accounting and similar machinery	682	677	885	972	1,218	179
Typewriters	226	207	264	259	253	117
Other office machinery	484	480	569	663	789	163
Printing and bookbinding machinery	1,851	1,930	1,912	1,979	2,683	145
Tobacco and cigarette-making machinery	593	676	769	802	741	125
Water-treatment plant‡	441	460	501	527	666	151
Industrial furnaces§	—	1,219	1,089	1,193	1,319	—
Watches	—	30	26	33	60†	—
Clocks, time recorders and switches	—	975	1,049	1,132	1,460¶	—
Railway points and crossings, brakes and signalling, telegraph and track equipment	1,032‖	1,062	1,201	1,344	1,330†	129
By Quantity (Thousands).						
Domestic cookers‡	215·2	181·7	221·8	221·4	262·8	122
Wash boilers	208·3	153·5	142·8	156·0	158·4	76
Water heaters	205·6	153·5	148·5	122·7	85·3	41
Gas and electricity meters	629·5	550·3	652·4	703·5	817·4	130

* Excludes internal-combustion engines for aircraft, tanks, road vehicles and engines of over 1,500 b.h.p. for marine propulsion.
† Estimated. ‡ Including domestic equipment. § Excluding blast and open-hearth furnaces, and soaking pits.
‖ Quarterly average for whole of 1946. ¶ Quarterly rate during October and November.

TABLE II.—*United Kingdom: Estimated Numbers Employed in General Engineering.* (Thousands.)

	Men.	Women.	Total.	Index (1938 = 100).
1938, July	539·2	53·7	592·9	100
1939, June	637·4	67·3	704·7	119
1943, June	928·6	531·2	1,459·8	246
1944, June	871·3	483·2	1,354·5	228
1945, June	777·9	361·9	1,139·8	192
1946, June	709·9	192·5	902·4	152
December	761·8	177·0	938·8	158
1947, June	778·7	169·4	948·1	160
September	791·3	170·4	961·7	162
December	809·8	173·4	983·2	166

Some of the more spectacular increases in the value of output were achieved by the manufacturers of accounting and office machinery. Including typewriters, the output of which increased to a lesser extent, this section of the industry registered an increase of 62 per cent. during the year, the yearly rate of output during the last quarter of 1947 being over 9*l.* million, compared with 5·6*l.* million during the last quarter of 1946. Exports totalled 2·4*l.* million during 1947, about 31 per cent. of total production. The volume of exports, by weight, was twice, and the value nearly four times, the pre-war figures. This performance was achieved with a labour strength of about 16,000 compared with 5,500 in 1935, suggesting a considerable expansion of capacity. Manufacturers' statements during the year underline past achievements, but point out that foreign competition, mainly from the United States, is increasing steadily, emphasising that the rise in costs must be checked if the industry is to increase its exports further.

It was announced towards the end of the year that an entire factory producing typewriters and electric razors is to be transferred from Bridgeport, Connecticut, to Glasgow, where it is expected to employ about 1,000 people. During October, the Office Appliances Trades Association organised the Business Efficiency Exhibition at Olympia, where electrically-operated mechanical ledgers, automatic book-keeping machines, new types of adding machines, dictating machines, continuous stationery, silent typewriters, automatic card-index systems, and many other devices for administrative and executive offices were shown. The exhibition was considerably larger than when it was last held, in 1938. The general shortage of labour assures this industry of a growing home market, and there is evidence of a considerable overseas demand. Much will depend on the industry's ability to keep abreast of world technological progress.

Three other sections of engineering with a major part to play in economising labour are those making conveying and mechanical-handling machinery, portable power tools, and scientific instruments. Unfortunately, production figures are not available in respect of all types of conveying and mechanical handling machinery. Exports during 1947 amounted to 785,000*l.*, compared with 276,000*l.* before the war. The number of conveyors produced rose from 110 a month in 1944 to 222 a month during 1947, most being made for use in coal mines. Towards the end of the year, the average monthly production was well above 250, and further increases are expected during the current year. Only a small number, averaging 19 a month, was exported. The demand from the foundry trade is reported to be very heavy, because of the gradual mechanisation of foundries. A new type of demand is coming from the farms, where rising labour costs and shortage of suitable man-power have provided the necessary incentive to install mechanical handling equipment. Cranes, hoists and other lifting machinery are also being produced in increasing numbers. The volume of exports in 1947 was double the pre-war figure; and, by value, exports were greater (6·1*l.* million during the year, compared with 1·6*l.* million in 1938) than those of any other section listed in Table III, on page 318, which is a summary abstracted from the *Trade and Navigation Returns* for December, 1947. The shortage and rising cost of labour are also creating a considerable demand for portable power tools. No production statistics are available, but in 1947 exports totalled 2·2*l.* million, over 500 per cent. greater than pre-war. Manufacturing concerns reported great activity and large order books, production being limited only by shortage of materials.

The scientific instruments industry expanded considerably during the war and has contracted only slightly since. In 1939, the industry employed 48,300 people; in 1943, the war-time peak, it employed 82,300. Some contraction took place during 1945, to 63,100, but it expanded again to 69,100 in December, 1947, the number of men employed being greater than at any time during the war. Some of the industry's problems were outlined by Mr. J. E. C. Bailey, President of the Scientific Instrument Manufacturers' Association of Great Britain, when he addressed a meeting of the Parliamentary and Scientific Committee in August. Mr. Bailey complained that the shortage of labour prevented firms from producing to the full capacity of available plant. The shortage of instruments is reported to be acute, and large users, such as Imperial Chemical Industries, Courtaulds, Unilever, and others, have expressed anxiety about lengthening delivery dates. He remarked that the industry was largely concentrated in the London area, and that the Government had been reluctant to grant building licences for necessary expansion schemes; in fact, there had been no expansion since the war ended. Shortages of materials also affected production; the industry's steel allocation during 1947 was said to be only a quarter of the 5,000 tons required.

In April, 1947, the Physical Society held their 31st Exhibition at the Imperial College of Science and Technology, South Kensington; of the 147 exhibitors, 118 were in the trade section and 29 in the research and educational section. Many new types of instruments were brought out during the year, a number of which employed the electronic valve. The widest use of electronic control systems —servo-mechanisms—is found at present in the chemical and allied industries, where the trend is towards continuous operations under automatic control; but other uses are rapidly being found, for example, in the control of machine tools, and are likely to contribute greatly to the acceleration of mass-production processes.

Exports of instruments during 1947 amounted to 6·4*l.* million, of which 65 per cent. consisted of medical, surgical, ophthalmic, optical and photographic instruments and the remaining 45 per cent. largely of instruments for industrial application. Competition in world markets is most likely to come from the American industry in the immediate future. American manufacturers are endeavouring to standardise their products to speed up production and reduce manufacturing costs. The German industry, which, before the war, was the largest in the world, has suffered little damage, and it is estimated that 90 per cent. could start manufacturing on a large scale if materials became available. It has been suggested by British manufacturers that the German industry should be more strictly controlled until they are able to increase their own production and to secure sufficient foothold in overseas markets. The only control at present is that of the Agency Import Commission, which fixes prices; but Mr. Bailey, in the address quoted above, considered that the German industry was in a position to compete with the British industry and to undersell it in many overseas markets.

Important sections of general engineering on which information has become available recently are those manufacturing ball and roller bearings, industrial valves, chains and pumping equipment. Shortages of these items have tended to limit the output of the entire engineering industry since the end of the war. It will be seen from Table I that the quarterly output of ball and roller bearings increased in value from 3·5*l.* million during the second quarter of 1947 to nearly 4*l.* million during the last quarter. The labour employed increased from 17,300 in April to 18,200 in November. During 1946, problems of reconversion considerably affected all large manufacturers, and the shortage of labour aggravated the difficulties. The Hoffmann Manufacturing Company, for example, lost 1,000 of their

employees during 1945, and, finding recruitment extremely difficult in Chelmsford, decided to move the manufacture of ball and roller bearings to a Government-owned factory near Glasgow. The supply of labour has improved and the main companies are now benefiting from their post-war extension schemes.

No production statistics are available for the precision chain industry, but manufacturers' statements suggest that output rose appreciably throughout the past year. Mr. Charles G. Renold, chairman of the Renold and Coventry Chain Company, stated at the annual general meeting of his company in November: "During the year, our sales reached a new high level, being some 6 per cent. greater in volume than in the previous year. This increase was again limited by available space, supplies and labour . . . but the gradual removal of bottlenecks is having its effect and total production is more nearly approaching the existing capacity ceiling. Full double shifts were employed wherever the labour was available, but interruptions in the supply of steel mitigated against maximum efficiency."

The production of industrial valves rose by nearly 60 per cent. during 1947, from 1·7*l.* million during the fourth quarter of 1946 to 2·8*l.* million during the fourth quarter of 1947. The production of pumps and pumping equipment shows a smaller, but steady, increase throughout the year, from 2·1*l.* million to 2·8*l.* million. Exports totalled 1·5*l.* million, compared with 646,000*l.* in 1938, representing approximately 14 per cent. of total production. The percentage of ball and roller bearings exported was less than 10 per cent. during the last quarter of the year. This is a clear indication that British industry is being supplied first, and that the policy is to keep direct exports as low as possible. Indirect exports, as components of exported machinery, are probably as high as the direct exports of the majority of other engineering products. It should be noted, however that, by volume, the direct exports of ball and roller bearings and pumping equipment are higher than pre-war, by 13 per cent. and 74 per cent., respectively.

Many other sections of engineering are included in Table I; the last column, which shows deliveries during the last quarter of 1947 as a percentage of those in the last quarter of 1946, is sufficient evidence that a general and substantial improvement has taken place during the year. Prime movers and boilers (excluding water-tube boilers, which were discussed in a previous article) have registered increases in the quarterly rate of output ranging from 57 to 79 per cent. Internal-combustion engines were being produced at the annual rate of 26*l.* million during the last quarter; shell boilers at the annual rate of 6·7*l.* million; and steam-raising plant accessories at the annual rate of 10*l.* million. It is reported that the rate of output still lags behind the rate at which orders are being received, but there is evidence that an increasing number of firms are producing to the full capacity of available plant and equipment.

Certain machinery sections supplying consumers goods industries, such as printing and bookbinding machinery, tobacco and cigarette-making machinery and boot and shoe machinery, have registered smaller increases in their rate of output than those supplying capital-goods industries. It is difficult, of course, to ascertain how far any of the increases registered in the value of output reflects price increases. The annual rate of production of printing and bookbinding machines rose from 7·4*l.* million in the last quarter of 1946 to 10·7*l.* million in the last quarter of 1947, an increase of 45 per cent. over the year. Exports totalled 4·1*l.* million, nearly four times the pre-war level, and amounted to 48 per cent. of total deliveries. Exports of tobacco and cigarette-making machinery amounted to nearly 60 per cent. of total deliveries, being 221 per cent. greater than in 1938. It should be noted, however, that the export price per ton of this machinery was 75 per cent., and that of printing machinery 85 per cent., greater than in 1938.

An interesting development in British precision-engineering industry, closely connected with the production of scientific instruments, is the considerable expansion of the watch and clockmaking industry. The value of the output of watches was at the rate of about 250,000*l.* a year at the end of 1947, and that of clocks at the rate of nearly 6*l.* million. The industry plans to reach an output of 8,000,000 clocks by 1950, which would represent an increase of some 150 per cent. on the 1947 level. Before the war, the most severe competition came from Germany, which had the largest clock-producing industry in the world, with an annual output of approximately 15 million, of which 3 to 4 million were exported to this country at a price far below British production costs. Germany is still potentially a large producer, its industry, located in the Black Forest, having escaped serious damage during the war. Serious competition is also expected from the United States, but British manufacturers hope that the volume of production they have planned will allow them to reduce costs sufficiently to compete successfully in world markets. During 1947, exports of clocks and watches totalled 1·1*l.* million, more than ten times the value of exports in 1938.

Since the end of the war, a shortage of iron castings has constituted one of the most serious obstacles to increased production of machinery. This has been quoted by the Evershed Commission's report on the weaving section of the textile-machinery industry as the determining factor in any attempts to increase the output of automatic looms, and the same factor has prevented an adequate supply of agricultural machinery, particularly ploughshares, to British farms. Deliveries of iron castings, as published in the *Monthly Digest of Statistics*, show that the average weekly rate has improved steadily since the end of the war, from 37,800 tons in 1945 to 47,100 tons in 1946 and 53,600 tons in 1947. Total deliveries during 1947 amounted to 2·7 million tons, and the industry aims at producing three million tons during the current year. The achievement of the target is said to be more dependent on adequate supplies of raw materials than on the additional recruitment of labour. It was estimated at the end of the year that the shortage of pig iron and scrap caused the industry to work at only about two-thirds of capacity. In the normal course, the industry would use something under two million tons of pig iron, plus slightly more than a million tons of scrap, to achieve its target in 1948. Because of the scrap shortage, however, the rate of intake of pig iron is

TABLE III.—United Kingdom: Exports of Certain Industries Classified as "General Engineering."

Type of Product.	Volume (Tons).			Value (£1,000).			1947 as Percentage of 1938.	
	1938.	1946.	1947.	1938.	1946.	1947.	Volume.	Value.
Air and gas compressors and exhausters	3,640	4,082	5,800	572	1,242	1,924	160	337
Boot and shoe machinery	456	503	547	166	332	413	120	249
Cement-making machinery	951	3,506	5,414	84	319	513	540	612
Centrifugal drying machinery	2,305	661	470	209	158	120	20	57
Concrete-mixing machinery	1,559	4,627	6,239	129	695	1,038	400	804
Condensers	1,998	1,320	2,475	296	311	702	124	246
Conveyors, telphers, transporters	3,080	3,196	5,158	276	444	785	168	284
Cranes, hoists and other lifting machinery	19,212	31,364	38,326	1,597	4,191	6,101	200	382
Dairy machinery	825	1,119	1,206	235	493	723	146	308
Excavating and similar digging machinery	5,776	9,059	14,314	687	1,665	2,937	248	427
Fans, power-driven	—	1,093	2,459	—	543	1,215	—	—
Food-preparation and sterilising machinery	2,331	3,347	4,948	376	982	1,879	213	500
Furnace plant	5,299	2,697	5,408	357	393	859	102	240
Gas and chemical machinery	4,166	5,784	5,426	328	785	999	130	304
Grain-milling machinery	1,975	4,787	5,791	236	1,037	1,467	293	620
Hydraulic machinery	2,503	1,596	2,003	253	295	416	80	164
Laundering and dry-cleaning machinery	1,141	1,144	2,057	149	294	631	180	423
Lawn mowers	760	2,282	3,703	138	491	844	490	612
Office machinery	986	1,594	1,973	637	1,814	2,365	200	372
Packing, packeting and labelling machinery	319	405	707	188	341	704	222	355
Portable power tools	570	1,435	2,472	345	1,011	2,151	434	624
Printing and bookbinding machinery	4,139	4,848	8,884	1,038	2,127	4,076	214	392
Pulp-making and paper-making machinery	7,223	1,685	1,962	729	422	577	27	79
Pumps	8,229	11,493	14,295	1,561	3,155	4,778	174	306
Road rollers	2,799	2,414	8,654	253	355	1,675	310	662
Rolling-mill (metal-working) machinery	4,568	3,900	5,284	332	352	523	115	157
Sewing machines and parts	11,709	6,904	9,472	1,262	1,942	2,394	81	189
Tobacco and cigarette-making machinery	983	1,415	1,903	522	1,168	1,772	194	321
Weighing machinery	2,138	2,760	3,399	259	526	814	159	314
Welding machinery	—	9,409	7,176	—	1,562	1,847	—	—
Woodworking machinery	1,441	2,584	3,237	231	565	917	224	396
Ball and roller bearings	1,691	1,950	1,904	646	1,329	1,521	113	246
Medical and surgical instruments	—	—	—	465	1,891	1,801	—	388
Photographic instruments	—	—	—	133	480	794	—	595
Ophthalmic instruments	—	—	—	42	281	225	—	536
Optical instruments (including photographic lenses in 1938)	—	—	—	163	487	740	—	454
All other scientific instruments	—	—	—	903	2,067	2,875	—	318
Clocks and watches	—	—	—	103	466	1,140	—	1,100
Total	10,772	134,963	183,066	15,900	37,011	57,255	175	360

TABLE IV.—*United Kingdom: Employment in Constructional Engineering.* (Thousands.)

—	Men.	Women.	Total.	Index (1938 = 100).
1938, July	39·7	1·8	41·5	100
1939, June	47·1	1·9	49·0	118
1945, June	40·9	8·0	48·9	118
1944, June	38·8	7·9	46·7	112
1945, June	35·7	6·2	41·9	101
1946, June	49·0	7·5	56·5	131
December	58·3	8·2	66·5	160
1947, June	59·0	7·2	66·2	158
September	58·0	6·9	64·9	165
December	58·3	6·6	64·9	165

TABLE V.—*United Kingdom: Exports of Iron and Steel, and Manufactures Thereof.* (Value, £1,000.)

Exported to	1938.	1946.	1947.
Eire	1,392	2,840	3,251
Palestine	192	2,816	1,808
British West Africa	1,176	1,791	2,235
Union of South Africa	4,867	7,372	6,890
British East Africa	576	1,088	1,770
British India	3,249	3,712	5,173
Burma	401	697	1,937
British Malaya	1,415	1,628	1,886
Hong Kong	425	569	1,004
Australia	4,512	2,118	2,817
New Zealand	2,590	1,955	2,244
Canada	2,309	706	800
British West India Islands	950	1,184	1,554
Other British countries	2,421	3,844	5,222
Finland	337	1,835	2,570
Sweden	326	2,948	2,741
Norway	373	2,135	2,422
Denmark	1,267	6,237	3,981
Netherlands	1,057	4,472	3,562
Belgium	458	1,666	1,358
Switzerland	165	1,577	1,511
Egypt	632	2,410	1,614
Iraq	2,505	1,989	2,584
Iran	2,223	2,693	2,630
China	419	859	2,759
Venezuela	134	1,392	2,032
Brazil	450	1,497	1,351
Argentine Republic	1,727	3,428	3,453
Other Foreign Countries	3,115	12,364	10,592
Total	41,663	79,822	83,751

running well above this ratio, and ironfounders doubt if the foundry-iron blast-furnace capacity of the country is large enough to meet the probable demand, perhaps 2½ million tons, in 1948.

The supply of labour remains, on the whole, below full requirements, although recruitment is proceeding satisfactorily. The mechanisation programme will effect substantial savings in total requirements, and make possible the substitution of unskilled labour for many skilled grades now scarce. Towards the end of 1947, the Ministry of Labour published the report of the Joint Advisory Committee on Conditions in Ironfoundries (H.M.S.O., 1947). The Committee place considerable emphasis on cleanliness, good lighting, the adoption of colour schemes to relieve the drabness of foundries, adequate ventilation, better amenities, etc. They also recommend that every effort should be made to avoid the use of open fires, and suggest that new techniques should be developed to eliminate their use in those processes where no suitable alternative is at present known. The Committee's recommendations relating to moulds and core stoves centre on the prevention of the escape of offensive or injurious fumes into the works, suggesting that stoves should be provided with suitable flues and stacks, etc., to clear them of fumes before they are discharged, or that local exhaust ventilation should be provided to ensure that fumes are collected at the stove opening and carried to the open air. Recommendations on knocking-out vary according to the size and nature of the foundry, but, as a general measure, it is suggested that, where necessary and practicable, water should be used to suppress dust, and that the operation should take place in a separate room or in a separate part of the foundry.

The Committee's recommendations will take considerable time to become part of general foundry practice, but, once implemented, should prove effective in making working conditions more tolerable. Also announced in 1947 is the agreement between the British Government and the Italian Government for the recruitment of Italian labour for British foundries. The agreement was published as a White Paper (Cmd. 7168) in July. By the end of August, 257 Italians had arrived in this country and had been allocated among 32 firms. They are employed under full trade-union conditions and rates of pay, and are required to join the appropriate British trade union.

The activity of constructional engineering firms is likely to be substantially reduced during 1948 through the Government's decision to cut down the allocation of steel for building work of all types. Employment contracted slightly during 1947, from 66,200 in June to 64,900 in December (see Table IV, opposite). In the first six months of 1948, no new industrial building is being started and much of the work in progress when the White Paper on *Capital Investment* was published, which had not reached the steel erection stage, is being reviewed with the object of postponing at least half of it. Civil engineering schemes, such as the reconstruction of the Notting Hill Gate station and Euston station, the Severn bridge, the Widnes-Runcorn bridge, the main tunnel under the Tyne at Jarrow, and several other schemes will be postponed.

Exports of iron and steel are set out in Table V, opposite, by countries of destination; the figures are taken from the *Trade and Navigation Returns*, December, 1947, as are those of the remaining tables in this article. The total value amounted to 83·7*l.* million, compared with 41·6*l.* million in 1938. Consignments to British countries accounted for just over 45 per cent. of the total, the leading customers being South Africa, India and Eire. Exports to foreign countries were mainly consigned to countries supplying important raw materials and food, such as Argentina, Denmark, Finland, Sweden and Norway. Substantial amounts, however, to various countries, including Holland, France and China, were probably unrequited exports, made to facilitate the entry of British goods to these countries. It is difficult to guess the Government's policy concerning future exports, but it is probable that large quantities will continue to be required to secure essential raw materials and foodstuffs, and that many countries will insist on supplies of iron and steel when negotiating bilateral trading agreements. Imports were small—14·9*l.* million—but over 60 per cent. were obtained from the United States and Canada.

Exports of non-ferrous metals are given in Table VI, on this page. The total value for 1947 was 39·4*l.* million, about 43 per cent. of which was consigned to British countries, the leading customer being British India. Exports to foreign countries went mainly to Belgium, Holland and Sweden; the United States accounted for 1·4*l.* million. Imports of non-ferrous metals are shown in Table VII, on this page. It will be seen that the bulk of the supplies were obtained from American countries, 22·3*l.* million from Canada, 13·4*l.* million from the United States, and 7·5*l.* million from other American countries. Imports from these sources amounted to more than 57 per cent. of the total, and it is evident that, unless Britain's supplies of dollars are replenished in the near future, considerable and crippling shortages of non-ferrous metals will follow.

TABLE VI.—*United Kingdom: Exports of Non-Ferrous Metals and Manufactures Thereof.* (Value, £1,000.)

Exported to	1938.	1946.	1947.
Eire	375	749	1,097
Union of South Africa	784	1,487	2,030
British India	989	5,999	5,462
Ceylon	94	205	1,347
Australia	630	872	1,251
New Zealand	454	665	1,202
Other British Countries	1,366	4,439	4,799
Sweden	587	2,397	2,229
Norway	168	1,003	1,567
Denmark	168	1,883	1,239
Netherlands	249	2,850	2,062
Belgium	240	1,220	3,136
France	673	2,720	1,361
United States	742	2,358	1,447
Other Foreign Countries	3,814	8,772	9,150
Total	11,333	37,619	39,379

TABLE VII.—*United Kingdom: Imports of Non-Ferrous Metals and Manufactures Thereof.* (Value £1,000.)

Country of Origin.	1938.	1946.	1947.
Northern Rhodesia	3,862	8,229	15,413
Australia	3,385	4,070	10,039
Canada	14,756	16,643	22,341
Other British countries	2,455	368	675
Belgium	1,279	800	5,921
Belgian Congo	18	1,966	1,851
United States	2,042	2,129	13,361
Other American Countries	6,250	5,263	7,549
Other Foreign Countries	6,167	1,309	2,105
Total	40,804	40,777	79,255

TABLE VIII.—*United Kingdom: Exports of Machinery.* (Value £1,000.)

Exported to	1938.	1946.	1947.
Eire	1,609	3,669	5,848
Palestine	186	2,750	3,123
British West Africa	1,059	1,372	1,862
Union of South Africa	7,502	9,937	14,375
Southern Rhodesia	442	1,150	1,236
British East Africa	505	1,247	2,272
British India	7,336	19,335	29,985
Burma	428	978	2,297
British Malaya	1,692	1,816	3,255
Australia	4,811	6,297	10,635
New Zealand	1,692	3,331	4,521
Canada	1,558	2,042	3,662
British West India Islands	613	968	1,259
Other British Countries	1,832	3,000	5,496
Soviet Union	3,348	5,712	10,409
Finland	548	1,035	1,563
Sweden	1,028	2,283	4,835
Norway	405	1,402	3,481
Denmark	519	2,029	2,897
Netherlands	1,975	4,164	6,490
Belgium	894	2,166	5,453
France	1,422	5,297	4,880
Switzerland	285	874	1,831
Portugal	307	1,201	1,947
Spain	136	1,360	1,277
Czechoslovakia	245	624	1,312
Yugoslavia	452	1,088	2,344
Greece	133	641	1,030
Turkey	608	1,473	2,083
Dutch East Indies	330	338	1,207
Egypt	794	4,081	5,252
Iraq	432	1,563	2,670
Iran	1,157	2,218	2,332
China	1,013	825	2,578
United States	628	1,715	2,120
Venezuela	137	707	1,859
Brazil	1,226	2,549	4,497
Argentine Republic	1,339	2,194	5,310
Other Foreign Countries	6,059	7,679	10,280
Total	57,185	114,110	179,763

Exports of machinery are given in Table VIII, herewith. In 1947, these amounted to 179·8*l.* million, compared with 57·2*l.* million in 1938. The total volume was 58 per cent. greater than in 1938, but much remains to be achieved if the targets given by the Government in the *Economic Survey for* 1948 (Cmd. 7344) are to be achieved. The targets stipulate a gradual increase during the current year, the index being 174 (1938 = 100) during the first six months and 180 during the last six months, the average for the year being 177. The annual rate at the end of 1948 was estimated at 276*l.* million (at the forecast end-of-1948 prices). Data presented in previous articles certainly suggest that there may be some difficulty in achieving these targets, particularly if the supply of materials does not improve. During 1947, about half total exports of machinery were consigned to British countries. Leading customers were India (29·98*l.* million), South Africa (14·57*l.* million) and Australia (10·64*l.* million); Canada accounted for only 3·66*l.* million. The best foreign customer was Russia (10·41*l.* million), followed by Holland (6·49*l.* million), Belgium, Egypt and Argentina, with about 5*l.* million each. Including South Africa and Canada, exports to hard-currency countries amounted to approximately 19 per cent. of the total, compared with 23 per cent. in 1938. It should be stated that the countries considered to be those of hard currencies vary from time to time, in accordance with import restrictions, seasons, bilateral trading agreements, etc. The British Treasury is unwilling to be committed to a list of such countries, although at present the United States, Canada and Newfoundland, Argentina, Switzerland and Belgium are considered "hard," Sweden and Spain "moderately hard" and Italy "less hard." Imports of machinery during 1947 totalled 29·6*l.* million, practically all obtained from the United States and Canada.

TABLE IX.—*United Kingdom: Exports of Vehicles, Ships and Aircraft.* (Value £1,000.)

Exported to	1938.	1946.	1947.
Eire	1,407	3,239	6,263
Channel Islands	298	1,168	1,486
Palestine	149	1,794	1,980
British West Africa	1,075	1,907	3,123
Union of South Africa	4,439	8,683	13,780
Southern Rhodesia	749	830	1,910
British East Africa	644	1,805	2,489
British India	3,288	13,164	12,337
Burma	195	1,819	3,215
British Malaya	1,003	2,532	4,251
Ceylon	460	686	1,710
Australia	5,386	6,944	7,963
New Zealand	3,620	4,676	8,051
Canada	694	1,684	3,261
British West India Islands	272	1,073	1,643
Other British Countries	1,009	2,955	5,116
Finland	489	1,170	1,184
Sweden	904	2,703	5,358
Norway	491	893	4,896
Iceland	2	605	2,541
Denmark	1,305	4,739	4,127
Netherlands	1,334	4,751	6,019
Belgium	672	3,193	7,060
France	588	8,817	7,114
Switzerland	260	1,491	3,287
Portugal	533	2,417	3,786
Spain	62	394	1,425
Czechoslovakia	84	1,569	1,636
Greece	1,471	429	1,142
Turkey	353	622	3,549
Dutch East Indies	250	283	1,040
Egypt	1,146	1,460	2,334
Iraq	460	600	1,058
Iran	887	1,409	2,093
United States	161	1,319	1,827
Brazil	416	1,772	2,902
Uruguay	216	822	1,054
Argentine Republic	4,027	4,580	11,779
Other Foreign Countries	3,680	14,501	12,398
Total	44,479	114,998	168,096

Exports of vehicles, ships and aircraft are given by countries of destination in Table IX, herewith. In 1947, they amounted to 168*l.* million, compared with 44·5*l.* million in 1938. The volume of exports during 1947 was 185 per cent. of the pre-war volume. Targets for 1948 stipulate an increase to 227 per cent. in the first six months and 240 per cent. in the second six months. About 42 per cent. of the total value of exports during 1947 were consigned to British countries, the main customers being South Africa (13·8*l.* million), British India (12·3*l.* million), and Australia (7·8*l.* million). The best foreign customers were Argentina (11·8*l.* million), France (7·1*l.* million), Belgium (7*l.* million), Holland (6*l.* million) and Sweden (5·4*l.* million).

COMMERCIAL MOTOR VEHICLE WITH UNDER-FLOOR ENGINE.

COMMER CARS LIMITED, LUTON.

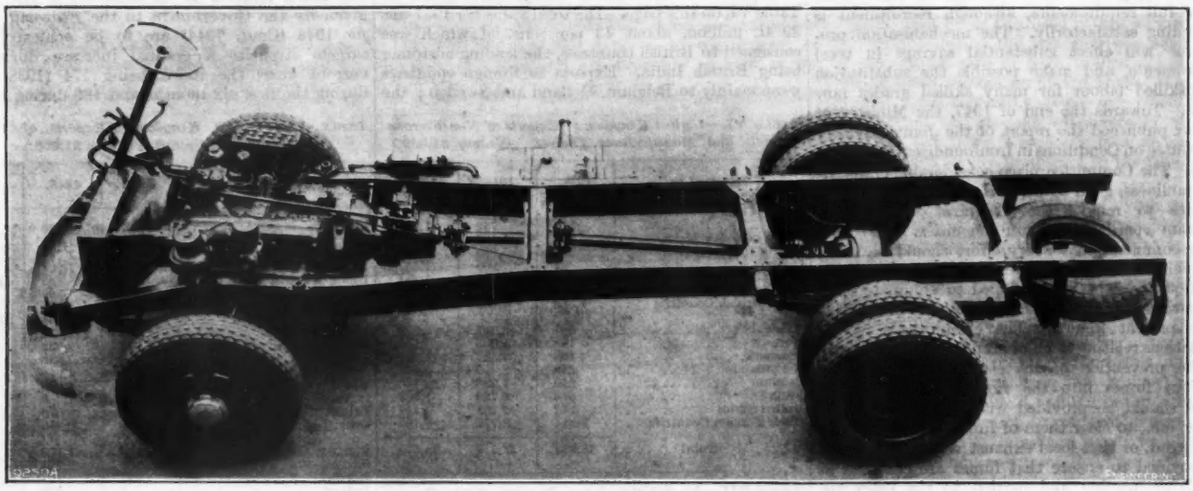
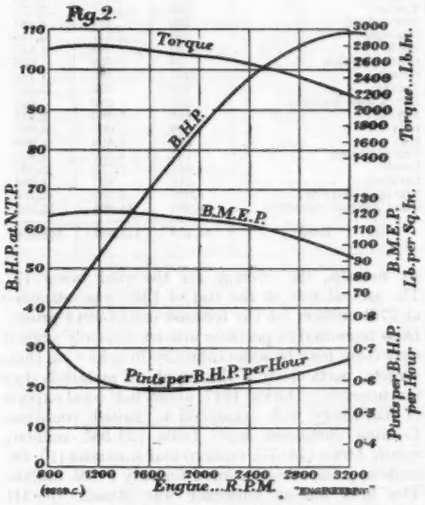


FIG. 1. GENERAL ARRANGEMENT OF 7-TON CHASSIS.



COMMERCIAL MOTOR VEHICLE WITH UNDER-FLOOR ENGINE.

MANY advantages can be claimed for the forward-control type of commercial vehicles, among which may be included better weight distribution, a shorter wheelbase, maximum loading space within the statutory limits, and good visibility. Nevertheless, on the majority of forward-control vehicles, the top of the engine projects into the driver's cab, with the result that, unless the engine is in good condition and exceptional care is taken with the fitting of the engine cowling, there is the danger of obnoxious fumes entering the driving compartment. Furthermore, the seating arrangements are restricted and the heat from the engine can render the cab uncomfortably hot during the summer months, which is a definite disadvantage when this type of vehicle is required for use overseas. In the latest design of commercial vehicle introduced by Commer Cars, Limited, Luton, however, the advantages of forward control have been retained, but the disadvantages referred to above have been eliminated. This has been accomplished by placing the engine underneath the floor of the driver's cab, a layout which has necessitated designing the engine so that the axes of the cylinders are set at 66 deg. to the vertical, thus making the engine more or less horizontal. A general view of the chassis is shown in Fig. 1, on this page, while Fig. 3 shows the engine installation in greater detail, and it will be seen in the latter illustration that the chassis side members are set wider apart at the front in order to give sufficient space for the engine. At first sight, it would appear that placing the engine in this position renders it inaccessible, but the engine has been designed so that those components likely to require attention are grouped on the top of the engine, access to which is obtained through removable panels fitted underneath the seats. The vehicle is available either as a 5-ton or a 7-ton load carrier, but with the exception of the back-axle ratios, tyre sizes and some other minor items, both models are identical. The complete vehicle is illustrated in Fig. 4, opposite, which shows the 5-ton model fitted with a platform body.

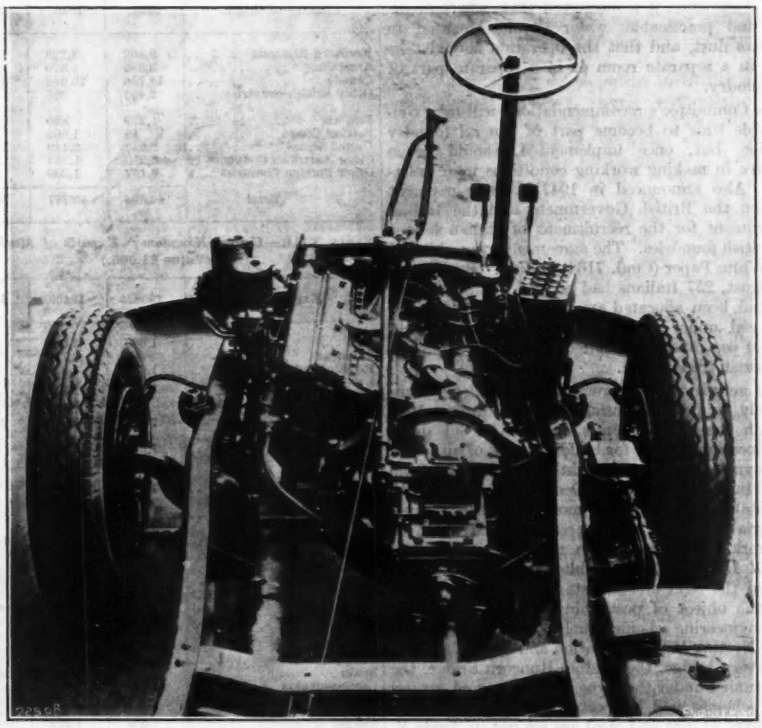


FIG. 3. ARRANGEMENT OF ENGINE INSTALLATION.

The engine is a six-cylinder overhead-valve petrol unit having a bore and stroke of 3¾ in. and 4½ in., respectively. It is illustrated in Fig. 5, opposite, while the performance curves are given in Fig. 2, on this page, from which it can be seen that the maximum output at the governed speed of 3,000 r.p.m. is 109 brake horse-power and the maximum torque is 2,760 lb.-in. at 1,000 r.p.m., the latter figures corresponding to a brake mean effective pressure of 120 lb. per square inch. The cylinder block and crankcase form a single casting, and, as previously mentioned, the axes of the cylinders are set at 66 deg. to the vertical. The cooling-water jackets extend the full length of the cylinders and the bores are plated with porous chromium. Aluminium-alloy pistons are fitted, each having two compression rings and one oil-control ring above the gudgeon pin; in addition, a plain ring is fitted below the gudgeon pin, which can be replaced by an oil-control ring when required. The cylinder head is a single detachable iron casting and is fitted with overhead valves operated in the usual manner by push rods and rocking levers. The inlet valves are made from silicon-chrome steel and the exhaust valves from austenitic steel, the latter operating in renewable guides. The camshaft is a solid-steel forging with integral cams and is driven from the front-end of the crankshaft by a double roller chain the tension of which is adjusted automatically. The camshaft runs in four white-metal lined bearings and it is fitted with a skew gear, for driving the distributor and oil pump, and an eccentric for operating the fuel pump. The crankshaft is forged from 55-ton steel and runs in seven

MOTOR VEHICLE WITH UNDER-FLOOR ENGINE.

COMMER CARS LIMITED, LUTON.

FIG. 4. PLATFORM BODY FITTED TO 5-TON CHASSIS.

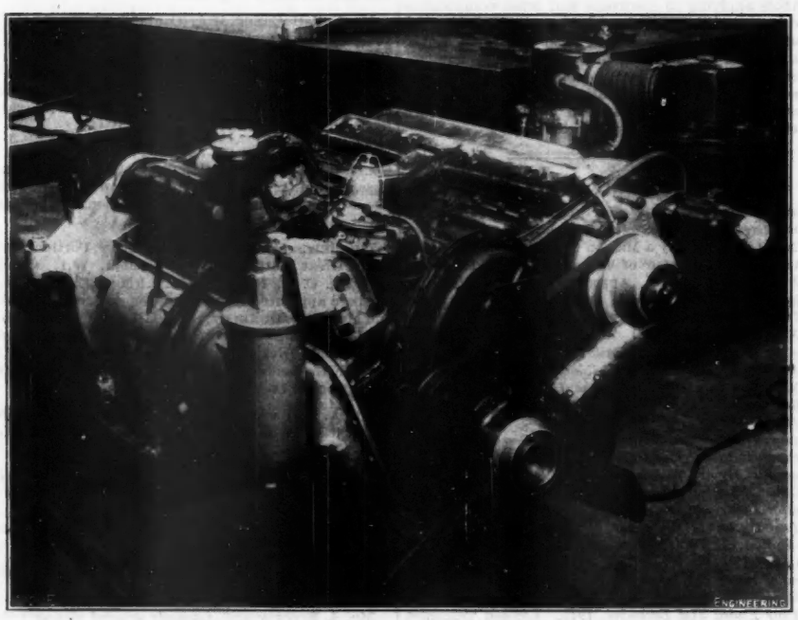


FIG. 5. SIX-CYLINDER OVERHEAD-VALVE PETROL ENGINE.

steel-backed white-metal lined bearings secured to the crankcase by girder-section caps. The connecting rods are I-section steel stampings, and the small ends are fitted with lead-bronze bushes, while the big ends, like the main bearings, are of the steel-backed white-metal lined type.

The cooling system is thermostatically controlled and the water pump is driven from the front end of the crankshaft by a single V-belt, which also serves to drive the dynamo. The fan is carried on an extension fitted to the front end of the crankshaft and is connected thereto by a rubber coupling, which acts as a torsional vibration damper. This arrangement, together with the belt drive to the water pump and dynamo, can be seen in Fig. 5. Oil is supplied under pressure by a gear-type pump to the main bearings, the crankshaft being drilled for the lubrication of the big ends, and oilways cast in the crankcase feed the camshaft bearings and overhead valve gear. The oil pump, as previously mentioned, is driven from the camshaft through skew gears, and the oil passes through a gauze strainer which enshrouds the pump inlet, and a full-flow filter fitted into the pressure line; the filter is fitted with a spring-loaded relief valve. A Solex 46-mm. down-draught carburettor is fitted which incorporates an accelerating pump, an easy-starting device and a sealed governor. The mixture is distributed through a six-branch aluminium manifold which is fitted with a copper-plate "hot-spot"; the carburettor intake is provided with an oil-bath type air filter. Coil ignition is employed, the distributor being provided with automatic advance and retard control; as previously mentioned, the distributor is driven from the camshaft by skew gears.

The engine, clutch and gearbox form a single unit, which is supported in the chassis at three points by rubber mountings. The clutch is of the single dry-plate type and transmits the drive to a four-speed gearbox. The latter is an iron casting and the gears are carried by short stiff shafts which run in either ball or roller bearings. Constant-mesh helical gears are provided for third speed and the ratios for the various speeds are: top, 1 to 1; third, 1·788 to 1; second 3·366 to 1; first, 6·414 to 1, and reverse 8·246 to 1. As will be seen from Fig. 3, the selector mechanism is of the remote-control type. Provision has been made on the gearbox for the fitting of a power take-off and a tyre pump.

The drive from the gearbox is transmitted to the rear axle through open tubular-type propeller shafts fitted with Layrub universal joints, the after end of the leading propeller shaft being supported by a rigid-type ball bearing encased in rubber. The rear axle is of the fully-floating pattern, the casing of which is a steel casting fitted with nickel-steel extension tubes. The final drive is through a spiral-bevel and pinion unit, there being two separate ratios, one giving a reduction of 6·00 to 1 for the 5-ton model and the other giving a reduction of 7·14 to 1 for the 7-ton model. The overall reduction ratios for the 5-ton model are: top, 6·00 to 1; third, 10·73 to 1; second, 20·19 to 1, and first, 38·48 to 1. Those for the 7-ton model are: top, 7·14 to 1; third, 12·77 to 1; second, 24·03 to 1 and first, 45·8 to 1. The pinion shaft is fitted with an outrigger bearing and the combined differential and crown-wheel unit is supported by adjustable taper-roller bearings. The drive is transmitted to the wheel hubs through flanged-type axle shafts and the hubs are mounted on opposed taper-roller bearings in the usual manner. The front axle is an I-section high-tensile steel forging and the king pins are fitted with roller-type thrust bearings; like the rear axle, the hubs are mounted on opposed taper-roller bearings.

As will be seen from Fig. 1, the chassis frame is of straightforward design, the channel-section side members having a depth of 8$\frac{9}{16}$ in.; the top and bottom flanges are 2$\frac{9}{16}$ in. and 3 in. wide, respectively. Reverse-cambered semi-elliptical springs are fitted and these are held to the chassis frame by hardened-steel pins which work in bronze bushes. The front springs have an overall length of 48 in., the width of the leaves being 2$\frac{1}{2}$ in., and each spring is fitted with nine leaves on the 5-ton model and with 10 leaves on the 7-ton model. The overall length of the rear springs is 54 in. and in this case the width is 3 in., there being 11 leaves for the 5-ton model and 13 leaves for the 7-ton model. A cam and roller type steering box is fitted, the ratio of which is 21 to 1; the drag link and track rod are self adjusting. The turning circle for the 5-ton model is 45 ft., and that for the 7-ton model is 50 ft.

Internal-expanding hydraulic brakes of the two-leading-shoe type are fitted; these operate on all four wheels and on the 5-ton model are applied directly by the pedal but on the 7-ton model, application is assisted by a vacuum-servo unit. On the 5-ton model, the front and rear brakes have diameters of 14 in. and 16 in., respectively, but on the 7-ton model both the front and the rear brakes have a diameter of 16 in. A hand parking brake is provided, and this is arranged to operate the rear brakes only through a system of rod and cable connections. Detachable steel-disc two-piece wheels are used and these are fitted with 34-in. by 7-in. tyres on the 5-ton model and 35-in. by 7½-in. tyres on the 7-ton model; in both cases, twin wheels are fitted to the rear axle.

Both the 5-ton and 7-ton models have a wheelbase of 11 ft. 9 in. and the track widths are 6 ft. 1$\frac{3}{4}$ in. and 5 ft. 7 in. for the front and rear wheels, respectively. In both cases the overall length of the chassis is approximately 20 ft. 10 in. and the distance from the front of the chassis to the back of the cab is 5 ft. 6$\frac{3}{4}$ in. This gives a maximum legal body length of 15 ft. 11 in., thus making 76 per cent. of the overall length available for load carrying, which is a creditable achievement. The weight of the chassis for the 5-ton model is 2 tons 5 cwt., while that for the 7-ton model is 2 tons 7½ cwt., the maximum permissible gross vehicle weights being 8 tons 5 cwt. and 10 tons 4 cwt., respectively.

With the exception of the vacuum-servo unit, the equipment for both types of vehicle is the same. A 12-volt positive-earthed electrical system is used, the battery having a capacity of 63 ampere-hours on a 10-hour rating. As previously mentioned, the dynamo is driven by a belt from the front end of the crankshaft; the dynamo is fan ventilated and a voltage-control unit is fitted in the charging circuit. The starting motor is of the axial-engagement type and it can be seen in position on top of the engine in Fig. 5. The usual instruments are provided, but the electric fuel-contents gauge has been arranged so that it can be used for measuring the engine-oil level in addition to the quantity of fuel. A socket is fitted to the dash-board for an inspection lamp and, in order to facilitate servicing, the electrical connections to the dashboard have been effected by a multi-point plug and socket. The cab is of all-steel construction and the engine-cooling system has been arranged so that it can be used to regulate the temperature of the driving compartment. This is accomplished by a system of shutters situated behind the grille fitted to the front of the vehicle; when the shutters are closed, hot air from the radiator impinges against the floor of the cab but when the shutters are opened, a stream of air at atmospheric temperature passes underneath the floor of the cab, thus effectively isolating the cab from the engine. The cab seats three people in comfort, and its design is such that either left-hand or right-hand steering can be fitted with equal facility.

LAUNCHES AND TRIAL TRIPS.

M.S. "Fulham X."—Single-screw vessel for the carriage of coal, specially designed for navigation on the River Thames, built by Messrs. Hall, Russell and Company, Limited, York-place, Aberdeen, for the Fulham Borough Council, London, S.W. 6. Main dimensions: 260 ft. by 39 ft. 6 in. by 18 ft. 9 in.; deadweight capacity, about 2,600 tons on a draught of 17 ft. 6 in. Two-cycle Diesel engine of 1,520 brake horse-power, coupled to a double-helical single-reduction gearbox by an electro-magnetic slip coupling, constructed by British Polar Engines, Limited, Helen-street, Govan, Glasgow, to give a designed speed of about 11¼ knots. Launch, March 11.

S.S. "Soestdyk."—Single-screw vessel for the carriage of latex and refrigerated and general cargoes, with accommodation for 12 passengers. Built and engined by Messrs. Harland and Wolff, Limited, Queen's Island, Belfast, for the Holland-America Line, Rotterdam. Main dimensions: 495 ft. by 65 ft. 6 in. by 41 ft. 6 in., loaded draught 29 ft. 6 in.; gross tonnage, about 10,100. Parsons triple-expansion double-reduction geared turbines, of 10,500 shaft horse-power, to give a designed speed of about 16 knots. Launch, March 11.

M.S. "Warora."—Single-screw cargo vessel, built by the Burntisland Shipbuilding Company, Limited, Burntisland, Fife, to the order of the British India Steam Navigation Company, Limited, Leadenhall-street, London, E.C.3, for service in Indian waters. Main dimensions: 350 ft. by 49 ft. 9 in. by 25 ft.; deadweight capacity, about 5,500 tons on a draught of 22 ft. 6 in. Three-cylinder opposed-piston Barclay Curle-Doxford Diesel engine of 1,780 brake horse-power, supplied by Messrs. Barclay, Curle and Company, Limited, Clydeholm Shipyard, Glasgow, W.4, and installed by the builders; designed to give a trial speed of 11¼ knots. Launch, March 12.

M.S. "Salamanca."—Single-screw cargo vessel, with accommodation for 12 passengers, built and engined by Messrs. Harland and Wolff, Limited, Queen's Island, Belfast, for the Pacific Steam Navigation Company, James-street, Liverpool, and will be employed on the owner's trade with the West Coast of South America. Main dimensions; 467 ft. by 62 ft. 6 in. by 30 ft. 9 in., loaded draught, 27 ft.; gross tonnage, about 7,000. Harland-B. and W. eight-cylinder double-acting two-cycle oil engine of 7,500 brake horse-power, giving a speed of about 15¼ knots. Trial trip, March 18, 19, and 20.

M.S. "Angola."—Twin-screw vessel, with accommodation for cargo and 734 passengers in four classes, built and engined by Messrs. R. and W. Hawthorn, Leslie and Company, Limited, Hebburn Shipbuilding Yard, Hebburn-on-Tyne, to the order of the Companhia Nacional de Navegação, Rua do Comercio, Lisbon, for their trade between Lisbon and the Portuguese East and West African colonies. Main dimensions: 549 ft. 8 in. by 67 ft. by 44 ft. 3 in. to shade deck; gross tonnage about 12,800. Two Hawthorn-Doxford six-cylinder single-acting two-stroke cycle opposed-piston oil engines developing 13,000 brake horse-power together, and giving a speed of 18 knots. Launch, March 24.

Waste-Paper Salvage.—In view of the serious paper position, a concerted effort is to be made by the Waste Paper Recovery Association and associated bodies to raise the collection of waste paper by 200,000 tons per annum. It is hoped to increase the salvage of waste paper by 100,000 tons before midsummer this year. To achieve this, business houses, industrial and manufacturing concerns, institutions and other organisations and individuals are requested to clear out old documents, correspondence, ledgers, account books, out-of-date reference books, plans, drawings and other similar matter that has ceased to be of value. A waste-paper merchant should be asked to collect the material; if the name of the local merchant is not known, the Waste Paper Recovery Association, 52, Mount-street, London, W.1 (Telephone: GROsvenor 3233) will supply the necessary information.

Institute of Physics.—The 1948 conference of the Stress Analysis Group of the Institute of Physics will be held in the English Theatre of the University of Birmingham, Edmund-street, Birmingham, 3, from April 13 to 15. The conference will open on the afternoon of April 13 with a discussion on "Stress Analysis and the Designer," led by Sir Donald Bailey, and the remaining sessions will be devoted to short papers by Mr. A. F. C. Brown, Mr. P. de K. Dykes, Col. H. T. Jessop, Mr. D. C. Johnson, Mr. R. G. Manley, Mr. C. Mylonas, Mr. C. W. Newberry and Mr. J. G. Yates. Attendance at the conference is open to all interested without fee or tickets, whether members of the Group or not, who should, however, first communicate with the secretary, Institute of Physics, 47, Belgrave-square, London, S.W.1. The honorary secretary of the Stress Analysis Group is Mr. E. K. Frankl, Cambridge University Engineering Department, Trumpington-street, Cambridge.

BRITISH STANDARD SPECIFICATIONS.

The following publications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

High-Carbon Bright Steel.—A new specification, B.S. No. 1407, covers high-carbon bright steel, a material generally referred to as "silver steel," used for general engineering purposes. The chemical composition of the steel is specified in the new publication, together with details of the process of manufacture, finish, the condition of the material on delivery and the tolerances allowed. The diameters of bars normally available and the corresponding symbols or numbers in the Stubs steel-wire gauge and the Lancashire pinion gauge are given in an appendix. [Price 2*s.*, postage included.]

Hard-Drawn Steel Wire.—Another new specification, B.S. No. 1408, concerns hard-drawn steel wire for springs for general engineering purposes. Four qualities of wire are included and the analyses of these are as given in B.S. No. 970, namely, En.49A, En.49B, En.49C, and En.49D. The section on general clauses contains details of manufacture, the provision of test pieces, methods of test and tolerances. Three ranges (in the case of steel En.49A, four ranges) of tensile-strength tests, for sizes up to 0·400 in. in diameter, are specified for each of the steels covered. [Price 2*s.*, postage included.]

Letter Symbols for Electronic Valves.—The importance of adopting a standard system of letter symbols for electronic valves will be generally recognised, and a new specification, B.S. No. 1409, prepared originally by the British Radio Valve Manufacturers' Association, with this end in view is, therefore, of considerable interest. The new publication specifies a series of symbols applying to electrodes and other components of valves, to different types of valves, and to electrical quantities used in connection with valve technique. The symbols are intended for use by valve manufacturers, in their catalogues and specifications, and by users of valves; their utilisation is also advocated in drawings and diagrams, and in technical literature generally. [Price 2*s.*, postage included.]

BOOKS RECEIVED.

Ministry of Fuel and Power, and British Intelligence Objectives Sub-Committee. Technical Report on the Ruhr Coalfield. By a Mission from the Mechanisation Advisory Committee of the Ministry of Fuel and Power. Volume III. Appendix No. 1. *Problems of Increasing Coal Output.* By Dr. Engr. Walter Vogel. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* net.]

Ministry of Transport. Railways Division. Railway Accidents. Report on the Collision Which Occurred on 6th November, 1947, at Herne Hill, on the Southern Railway. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 9*d.* net.]

Department of Scientific and Industrial Research. Forest Products Research. Bulletin No. 21. *Flooring Hardwoods.* By F. H. Armstrong. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* net.]

Central Electricity Board. Twentieth Annual Report, 1st January to 31st December, 1947. Whitehead Morris Limited, 72-78, Fleet-street, London, E.C.4. [Price 1*s.* net.]

London Passenger Transport Board. Fourteenth Annual Report and Statement of Accounts and Statistics for the Year Ended 31st December, 1947. London Transport Executive, 55, Broadway, Westminster, London, S.W.1. [Price 1*s.* net.]

Copper Development Association. Copper Underground: Its Resistance to Soil Corrosion. With Particular Reference to the Use of Copper Pipes for Underground Gas and Water Services. Offices of the Association, Kendals Hall, Radlett, Hertfordshire. [Free to approved applicants.]

The College of Aeronautics, Cranfield. Report No. 1. *Ignoration of Distortional Co-ordinates in the Theory of Stability and Control.* By Professor W. J. Duncan. Report No. 2. *Note on the Application of the Linearised Theory for Compressible Flow to Transonic Speeds.* By A. Robinson and A. D. Young. Report No. 3. *On the Analysis of Statically Indeterminate Structures.* By W. S. Hemp. Report No. 4. *Technique of the Step-by-Step Integration of Ordinary Differential Equations.* By Professor W. J. Duncan. Report No. 5. *Note on the Dynamics of a Slightly Deformable Body.* By W. S. Hemp. Report No. 6. *The Effect of the Sweepback of Delta Wings on the Performance of an Aircraft at Supersonic Speeds.* By A. Robinson and F. T. Davies. Report No. 7. *Wing Body Interference at Supersonic Speeds.* By Dr. S. Kirkby and A. Robinson. Librarian, College of Aeronautics, Cranfield, Buckinghamshire. [Strictly limited issue: copies free to approved firms, Institutions and official bodies.]

PERSONAL.

Professor E. F. D. Witchell, F.C.G.I., B.Sc., M.I.Mech.E., and Mr. A. J. Breit, A.R.S.M., A.R.C.Sc., M.Inst.M.M., have been elected Honorary Fellows of the Imperial College of Science and Technology, London.

The administrators of the Sir George Beilby Memorial Fund, representing the Institute of Metals, the Royal Institute of Chemistry, and the Society of Chemical Industry, have made awards for 1947 to Dr. G. V. Raynor, M.A., F.R.I.C., F.Inst.P., for his researches on the constitution of alloy systems, and to Dr. G. R. Rigby, B.Sc., A.R.C.Sc., for his researches on refractory materials.

A list of departmental officers and principal assistants of the Railway Executive, London Midland Region, which has just been issued, contains the names of Mr. W. K. Wallace, M.I.C.E., chief civil engineer, and Mr. J. Briggs, M.I.C.E., assistant chief engineer. Mr. H. G. Ivatt, M.I.Mech.E., chief mechanical engineer; Mr. M. S. Hatchell, principal assistant (locomotives); Mr. A. E. Robson, principal assistant (carriages and wagons); and Mr. F. A. Harper, mechanical engineer (electrical). Mr. W. E. Yates, road-motor engineer, and Mr. V. R. B. Cooke, assistant road-motor engineer. Mr. T. M. Herbert, scientific research manager, and Mr. M. G. Bennett, general research manager.

Mr. J. R. Smith, O.B.E., who was Director of Merchant Ship Repairs, Western Mediterranean, from 1944 to 1948, is to take up an important administrative position, early in June, at the head office of Lloyd's Register of Shipping, 71, Fenchurch-street, London, E.C.3.

Professor C. E. Pearson, M.Met., first holder of the William Cochrane Chair in Metallurgy at King's College, University of Durham, created in 1945, is resigning this month to take up a post with Durham Chemicals, Limited, Birtley, Co. Durham.

Mr. V. C. H. Creer, M.A. (Cantab.), who was appointed general manager, lamp and lighting department, the British Thomson-Houston Company, Limited, has been appointed to the board of directors of the company, as from May 1, in succession to Mr. H. A. Lingard, who is shortly retiring owing to ill-health. Mr. Creer's office is in Crown House, Aldwych, London, W.C.2.

Mr. R. J. L. Eborall has been appointed head of the General Metallurgy Section and Mr. P. T. Gilbert, B.Sc., A.R.I.C., head of the Corrosion Section, British Non-Ferrous Metals Research Association, 81-91, Euston-street, London, N.W.1.

The British Electricity Authority, Portland Court, 170A, Great Portland-street, London, W.1, announce that Mr. C. G. Richards, A.M.I.Mech.E., A.M.I.E.E., has been appointed chief generation engineer (operation), and Mr. W. H. Dunkley, B.Sc., M.I.E.E., A.M.I.Mech.E., chief generation engineer (construction), in the Yorkshire Generating Division. Mr. W. McFarlane, B.Sc., A.M.I.E.E., has been appointed chief generation engineer (operation) in the South-West Scotland Division.

Mr. A. R. Bailey, B.Sc., A.I.M., has been appointed senior lecturer in metallurgy, at the Constantine Technical College, Middlesbrough.

Mr. Alexander Behr has been appointed export superintendent to Mono Pumps, Limited; he will act as liaison officer between the firm's head office, 67, Clerkenwell-road, London, E.C.1, and overseas agents.

Dr. E. W. Fell, M.Sc. (B'ham), F.R.I.C., F.I.M., has been appointed senior assistant in metallurgy, Bradford Technical College.

Mr. J. Belohoubek, formerly general manager of the Dyne Engineering Company, has joined the board of Messrs. Kamm and Company, Limited, electrical and scientific engineers, Powell-street, Goswell-road, London, E.C.1.

Mr. M. Patton, sales manager, power plant department, Messrs. Simon-Carves, Limited, Cheadle Heath, Stockport, relinquished this appointment on March 31. Mr. R. J. Cunningham will now handle all inquiries from Southern England at the firm's London office, Simon House, 6, Stratton-street, W.1. Mr. R. J. Jamison will deal with inquiries from Northern England at the firm's head office.

Mr. B. W. H. Youlten has been appointed public relations officer to the British Road Federation, 4A, Bloomsbury-square, London, W.C.1, in succession to Mr. M. C. Hall, who has relinquished the post.

Messrs. Peter Stubs Limited, Warrington, have appointed Mr. W. H. Walker, 53, Cromwell-road, Stretford, Manchester, to be their representative for the sale of their tools and silver steel in the Yorkshire area.

The Export Promotion Department, Board of Trade, are removing from 35, Old Queen-street, to Thames House North, Millbank, London, S.W.1, as from April 3. (Telephone: VICtoria 9040, as before, but the telegraphic address is to be Advantage London.)

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—The raw material position at the steelworks has been partly consolidated by the arrival of a few cargoes of German scrap at Grangemouth, and the recent high level of steel production has been fully maintained. There has been also a definite improvement in local scrap collections. Substantial tonnages of steel items are being regularly shipped from Scots ports to complete overseas orders, and makers and re-rollers are fairly well placed so far as Period I quotas are concerned. Makers have been intensifying efforts to clear off by to-day as many as possible of the old orders due for cancellation or re-authorisation. Any proportion unfulfilled is generally being regarded as definitely lost. This drastic result is deprecated by Scottish makers, but they are hopeful that the new authorisation scheme will be found to give greater general satisfaction if it is operated according to plan and establishes a more realistic relationship between authorised tonnages and the capacity of the industry.

Scottish Coal.—Following complaints from minor union officials that there were people in responsible positions in the coal industry who knew little or nothing about the industry, the Scottish Area of the N.U.M. have decided to make an inquiry into the operations of the N.C.B. They have approached the Board for the names and number of all officials in the industry, stating that the information will be supplemented by details of alleged overstaffing and inefficiency gleaned by union officials. The union state they are aiming at improving the efficiency of the industry. The N.C.B. surprisingly agreed to give most of the information sought, without divulging names. The recent reduction in the number of unofficial stoppages has been maintained, although there has been the odd case of a pit on strike for a day or so over some local grievance. Outputs have accordingly been steadier at a slightly higher level, but the target is still not reached by the Division. In general, supplies have been adequate to meet the requirements of all classes of consumers. The main complaint at the moment is the shortage of graded fuels. Industrial consumers are holding ample stocks, while throughputs are smaller owing to the reduced needs for space-heating. Round coal has been in slightly better supply from both deep mines and opencast sites. A number of house coal merchants are still not taking up the full quantity offered. Coke-oven needs are being met fully and export business has been quietly active. Recent sales included 4,000 tons of Fife duff to Dakar, and 3,100 tons of coal for Finland. Regular cargoes have been moving from Fife to Sweden and Denmark, with an occasional shipment for France. A small part cargo of duff was stemmed last week for Portugal. Irish business included parcels from Ayr to Dublin aggregating upwards of 2,000 tons of washed singles and round coal.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Production was accelerated before the Easter holidays with the object of completing specific jobs. Steelmakers have been trying to comply with the pressing demands from mills and forges for billets and slabs needed to ensure the restoration of continuous runs at the mills. The abolition of the "M" form from April 1, it is hoped, will lead to improved deliveries of high-carbon steels to numerous makers of steel products. Engineering firms have put into operation some heavy machine tools from Germany, and others are being erected. There is still a pronounced scarcity of both heavy and light machine tools. All tool factories engaged in the manufacture of engineers' small tools and edge tools are busily employed.

South Yorkshire Coal Trade.—Much improved production was attained before the holidays; there was a full attendance at the pits, including the morning shift on Good Friday, but there were an increased number of absentees from the afternoon shift. Best qualities have been allocated in increased quantities for shipment abroad, and there have been also bigger allocations of locomotive hards for holiday-train traffic. The house-coal demand has eased considerably and at the same time supplies have become more ample. More coking coal has reached the coking plants, which were able to operate fully during the holiday period at the pits.

WAGON REPAIRS AT SWINDON.—The rate of repairing wagons at Swindon Works has been increased by approximately 2,000 per annum, by transferring the work from an open-air site to the Newburn carriage shed, which has been rehabilitated for this purpose.

INQUIRY INTO EXPLOSION ON M.S. "REINA DEL PACIFICO."—The formal investigation into the explosion on board the M.S. Reina del Pacifico in Belfast Lough on September 11, 1947, has been fixed for hearing at Crumlin-road Court House, Belfast, on Tuesday, April 20, at 10.30 a.m.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Welsh Coal Trade.—Some indication of the progress made in South Wales towards recovering lost export trade has been given by Sir Cyril Hurcomb, chairman of the British Transport Commission, in the course of a three-day visit of inspection to the area. During the first twelve weeks of this year, he said, coal shipments from the local docks amounted to 1,205,364 tons, as against 1,085,406 tons in the same period a year ago, and 3,977,573 tons in 1939. Coastwise and bunker shipments continued to account for nearly three-quarters of this total, however, and in the period under review of this year coastwise deliveries totalled 663,420 tons and bunkers 208,776 tons. Nevertheless, an excellent start had been made and the re-opening of many old-established markets for Welsh coal had been very encouraging. In the first 12 weeks, the Argentine took 61,945 tons; Eire 50,596 tons; Northern Ireland 47,913 tons; Portugal 36,937 tons; France 27,646 tons; Brazil 7,907 tons; and Uruguay 4,904 tons. Canada was receiving shipments of Welsh anthracite. Two hoists, each capable of handling an extra 600,000 tons of coal per annum, have been brought back into commission at Barry, and as the volume of export trade increases further hoists will be recommissioned at other ports. The output from the Welsh mines reached its highest total for the year in the week ended March 20, when it amounted to 470,300 tons, compared with 457,029 tons in the previous week. The voluntary Saturday shift provided 32,994 tons. Trading conditions still remain difficult on the steam-coal market. Existing contracts from the principal home consumers were sufficient to ensure the steady lifting of the better sorts for some time to come. In addition, there is a good demand from ordinary industrial sources. Exports proceeded along steady lines under existing allocations, and little further expansion is expected before the seasonal slackening in home requirements. When that happened a larger quantity would be available for export.

Swansea Steel-Sheet Industry.—The market report issued by the Incorporated Swansea Exchange states that the demand for tin-plate continues to be in excess of the production. This, it is pointed out, could be increased if larger quantities of steel were available. Steel sheets continue in great demand, while iron and steel scrap is much sought after.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The demand for iron and steel continues considerably greater than the production. Exports are not on as large a scale as was expected, but this is not due to lack of interest on the part of overseas buyers; an early substantial increase of export trade is confidently anticipated. Meanwhile, the demand for large deliveries of material for home purposes continues and great quantities of the priority categories are reaching customers. Some further increase in yield of the Cleveland ironstone mines is reported, and coal supplies are satisfactory, but the provision of coke for the blast-furnaces presents special problems, particularly in regard to quality. Inadequate supplies of foundry pig iron, in addition to the scarcity of cast-iron scrap, are restricting the output of much needed castings. Good heavy steel scrap is also in short supply.

Foundry and Basic Iron.—There is no indication of a resumption in the make of ordinary Cleveland foundry pig and the output of a substitute quality is irregular and light, with the result that North-East Coast foundry owners are still dependent on iron supplies from distant producing centres. The output of basic iron is sufficient for the requirements of the makers' consuming plants.

Hematite, Low-Phosphorus and Refined Iron.—East-Coast hematite firms are maintaining deliveries on a scale sufficient for users' essential needs, but are still unable to provide larger deliveries to enable stocks to be built up. Outputs of low- and medium-phosphorus grades of iron are passing steadily into use and available parcels of refined iron are readily taken up.

Manufactured Iron and Steel.—Manufacturers of semi-finished and finished iron have as much work in hand as they can deal with and the delivery obligations of the steel producers absorb the outputs as soon as they become available. Certain classes of steel semies are less scarce than they have been for some time, but users continue to demand larger supplies. Makers are sending more billets and slabs to the re-rolling mills and increases in the imports of Continental billets and sheet bars are expected. The demand for maximum deliveries of finished steel commodities continues, although supplies over the first quarter of the year have exceeded anticipations considerably. Shipbuilders are receiving substantial parcels. The outputs of colliery equipment are moving promptly into use, and railway and other requisites, are still wanted in very large quantities.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

SOCIETY OF ENGINEERS.—Monday, April 5, 5.30 p.m., Geological Society, Burlington House, Piccadilly, W.1. "Filtration," by Mr. C. G. Vokes.

INSTITUTION OF SANITARY ENGINEERS.—Monday, April 5, 6 p.m., Caxton Hall, Victoria-street, S.W.1. "Standardisation and the Sanitary Engineer," by Mr. A. F. B. Nall.

INSTITUTION OF ELECTRICAL ENGINEERS.—*North-Eastern Centre:* Monday, April 5, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. Annual Meeting. "A New Electron Microscope," by Mr. M. E. Haine. *South Midland Centre:* Monday, April 5, 6 p.m., James Watt Institute, Birmingham. "Large Vertical-Shaft A.C. Generators Driven by Water Turbines," by Messrs. E. M. Johnson and C. P. Holder. Also at *North-Western Centre:* Tuesday, April 6, 6 p.m., Engineers' Club, Manchester. *East Midland Centre:* Tuesday, April 6, 6.30 p.m., Loughborough College, Loughborough. "The High-Pressure Mercury-Vapour Discharge," by Messrs. V. J. Francis and W. R. Stevens. *Radio Section:* Convention on "Scientific Radio," Victoria-embankment, W.C.2. Wednesday, April 7, 2 p.m., Session I. "Standards and Measurements;" 6 p.m., Session II. "Progation." Thursday, April 8, 2 p.m., Session III. "Radio Noise"; 6 p.m., Session IV. "Radio Physics." *Southern Centre:* Thursday, April 8, 7.30 p.m., Guildhall, Southampton. Faraday Lecture on "Electricity and Everyman," by Dr. P. Dunsheath.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, April 6, 5.30 p.m., Great George-street, S.W.1. "Use of Light Alloys in Structures," by Mr. R. A. Foulkes. *Birmingham Association:* Thursday, April 8, 6 p.m., James Watt Institute, Birmingham. Dugald Clerk Lecture: "Pumping Machinery," by Mr. H. R. Lupton.

INSTITUTION OF MECHANICAL ENGINEERS.—*Internal Combustion Engine Group* and *Automobile Division:* Tuesday, April 6, 6 p.m., Storey's-gate, S.W.1. "Piston Ring Movement During Blow-by in High-Speed Petrol Engines," by Dr. P. de K. Dykes. *London Graduates' Section:* Wednesday, April 7, 6.30 p.m., Storey's-gate, S.W.1. Joint Meeting with INSTITUTION OF CIVIL ENGINEERS (*London Students' Association*) and INSTITUTION OF ELECTRICAL ENGINEERS (*London Students' Section*). "Underground Railways." *Institution:* Friday, April 9, 5.30 p.m., Storey's-gate, S.W.1. Discussion on "District Heating," by Mr. A. Stubbs.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, April 6, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. Annual Meeting. "Standardisation," by Mr. S. J. Harley.

SHEFFIELD METALLURGICAL ASSOCIATION.—Tuesday, April 6, 7 p.m., 198, West-street, Sheffield. "Precision Casting," by Mr. H. Evans.

WEST RIDING FEDERATION OF ENGINEERING SOCIETIES.—Tuesday, April 6, 7.30 p.m., Technical College, Bradford. "High-Speed Photography in Engineering," by Mr. George A. Jones.

ROYAL SOCIETY OF ARTS.—Wednesday, April 7, 2.30 p.m., John Adam-street, W.C.2. "Craftsmanship: Codes of Work in Glass History," by Mr. W. A. Thorpe.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Northern Counties Branch:* Wednesday, April 7, 6.30 p.m., Neville Hall, Newcastle-upon-Tyne. Annual Meetiug. "Building Changes: Techniques and Technicians," by Mr. J. H. Napper. Thursday, April 8, 6 p.m., 11, Upper Belgrave-street, S.W.1. "The New Government Office Building, Whitehall," by Mr. C. F. Pike.

JUNIOR INSTITUTION OF ENGINEERS.—*Midland Section:* Wednesday, April 7, 6.30 p.m., James Watt Institute, Birmingham. "Development of the Gas Turbine," by Dr. E. A. Watson and Mr. O. N. Lawrence. *Institution:* Friday, April 9, 6.30 p.m., 39, Victoria-street, S.W.1. "Notable Arch Bridges of the Past," by Mr. R. P. Mears.

INSTITUTION OF PRODUCTION ENGINEERS.—*London Section:* Thursday, April 8, 7 p.m., Royal Empire Society, Northumberland-avenue, W.C.2. "Production of Gunnery Control Gear," by Mr. S. Parker.

ILLUMINATING ENGINEERING SOCIETY.—Thursday, April 8, 7 p.m., Municipal Technical College, Brighton. "Glassware for Lighting Fittings," by Mr. J. G. Holmes.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, April 9, 6.15 p.m., Mining Institute, Newcastle-upon-Tyne. "Modern Geared Turbine Installation in the Cargo Liner 'Asia'," by Mr. W. E. Loveridge.

ROYAL INSTITUTION.—Friday, April 9, 9 p.m., 21, Albemarle-street, W.1. "Mechanical Properties of High Polymers as Related to Their Structure," by Dr. Herman F. Mark.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Newcastle Branch:* Saturday, April 10, 6 p.m., Neville Hall, Newcastle-upon-Tyne. Annual Meeting and film display.

DE HAVILLAND PROPELLER-TEST BEDS AT HATFIELD.

(*For Description, see Page* 332.)

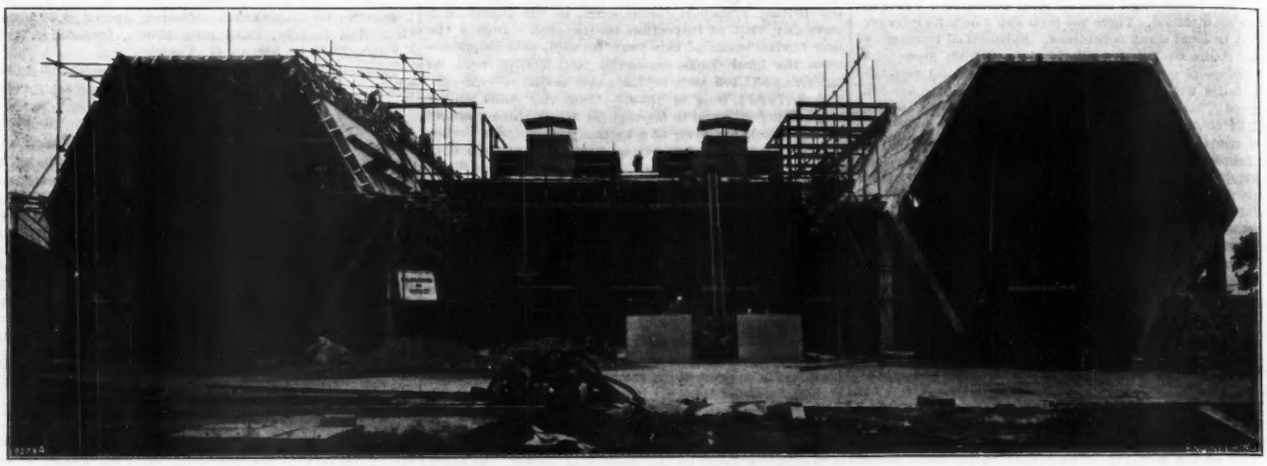


FIG. 1. GENERAL VIEW OF TEST BEDS NEARLY COMPLETED.

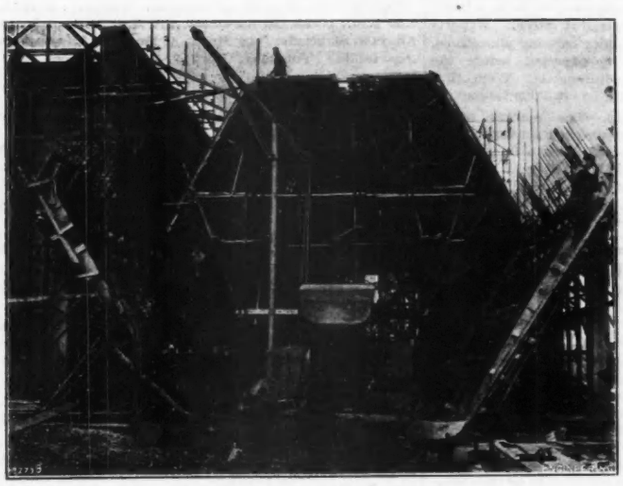


FIG. 2. TUNNEL UNDER CONSTRUCTION.

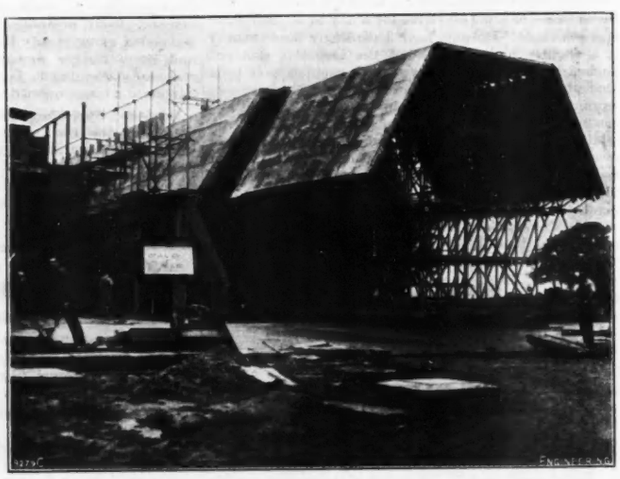


FIG. 3. TRAVELLING FALSE-WORK.

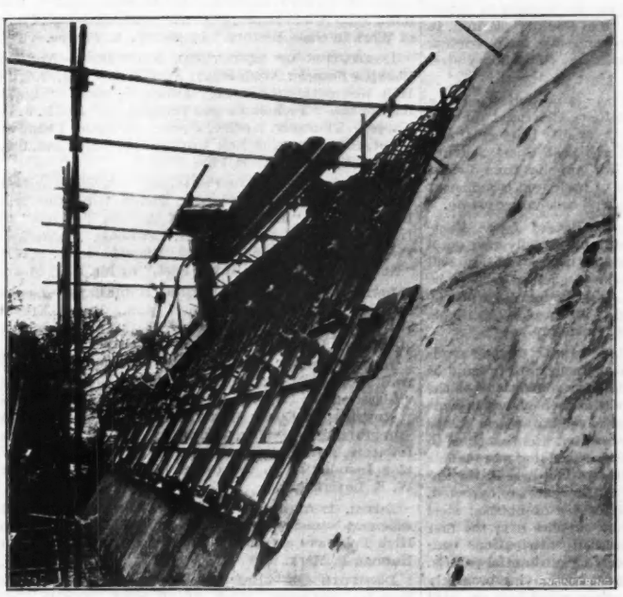


FIG. 4. REINFORCEMENT AND SHUTTERING.

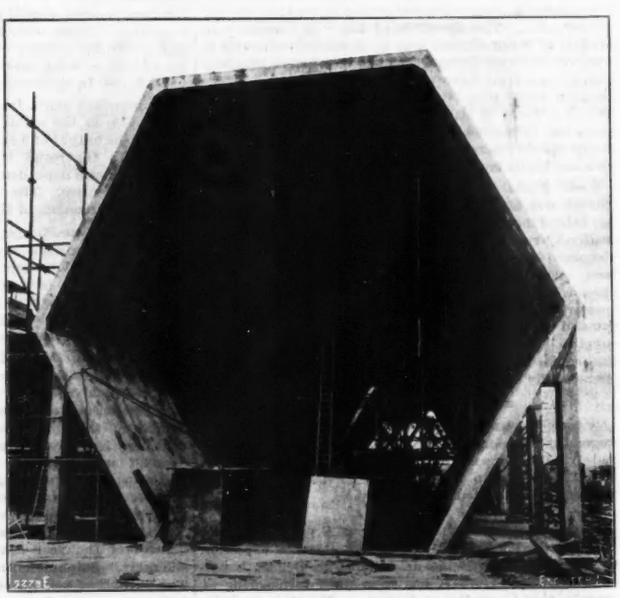


FIG. 5. REINFORCED-CONCRETE TUNNEL.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

Telegraphic Address:
"ENGINEERING," LESQUARE, LONDON.

Telephone Numbers:
TEMPLE BAR 3663 and 3664.

All editorial correspondence should be addressed to the Editor and all other correspondence to the Manager

Accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

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"ENGINEERING" may be ordered from any newsagent in town or country and from railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months (or for six or three months, *pro rata*), payable in advance:—

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The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

INDEX TO VOL. 164.

The Index to Vol. 164 of ENGINEERING (July-December, 1947) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications.

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ENGINEERING

FRIDAY, APRIL 2, 1948.

VOL. 165. No. 4288.

BRITISH ELECTRICITY SUPPLY.

YESTERDAY, April 1, 560 undertakings, which had supplied electricity to the public in this country, ceased their separate existence; and "all property, rights, liabilities and obligations" which they had possessed, became vested, by virtue of the Electricity Act, 1947, in the British Electricity Authority, or in one of the 14 subsidiary Area Boards established by the same statute. In future, the first of these bodies will undertake the generation and bulk supply of electricity to the Area Boards; and these Boards will be responsible for its distribution. Each area, as far as possible, will be managed autonomously; and, in the interests of operational and administrative efficiency, will be divided into a number of sub-areas. These sub-areas will again be divided into districts, the staffs of which will maintain direct contact with the consumers. For operational purposes, there will also be 14 generating divisions, the boundaries of which will coincide with those of the distribution areas.

Although this re-organisation of the British electricity supply industry will necessitate many fundamental administrative changes, it may be recalled that the conception underlying it is not new. In fact, it is just over thirty years ago since an Electric Power Supply Committee, which was appointed by the Board of Trade in 1917, under the chairmanship of Sir Archibald Williamson, recommended that "the parochial system" of generating and distributing electricity "should give place to more economical methods involving wider areas"; and that "one central authority to regulate" this generation and distribution should be established. It is therefore interesting to inquire why it has taken so long to bring about the necessary changes when it has been virtually common ground all this time that the recommendations of the Williamson Committee were sound in principle. In fact, if this country possessed no electric power supply system at the present time, and it was decided to construct one, it cannot be doubted that the organisation which would be set up for that purpose would be very similar to that which has now been established. It follows that the reasons for the delay, which at first are almost inexplicable, are neither technical nor commercial, but must be sought elsewhere.

Actually, they are not difficult to discover. Any account of the development of the British electricity supply industry, such as that which was given in Sir Archibald Page's presidential address* to the Institution of Electrical Engineers in 1927, or in the report of the McGowan Committee on Electricity Distribution† nine years later, clearly indicates that a fundamental mistake in organisation was made at the outset. Although this mistake was recognised before very long by the more enlightened electrical men, local political pressure, erroneous technical opinion, and an inability to recognise the immense potentialities which the future contained, all contributed to produce sufficient inertia to prevent real change.

That fundamental mistake, for which it would be hard to say the pioneers were wholly to blame, was, of course, the supposition that electricity supply was a matter of parishes and not of large areas or even whole countries. As is well known, the result of this narrowness of outlook, assisted by early legislative restrictions, was the establishment of a large number of small undertakings, the areas of which were determined by local government boundaries. The weakness of such an organisation was exposed by the increased demand for electricity during the 1914-18 war.

That a fundamental change was desirable, if not necessary, was then clearly indicated. What followed will be familiar, if not pleasant, reading. The main recommendations of the Williamson Committee were embodied in a Bill which was introduced in the 1919 session of Parliament and provided for the compulsory transfer of all generating stations and transmission lines to District Authorities. In its passage, these powers, however, were deleted; and the newly-established Electricity Commissioners were left to co-ordinate generation and transmission without, in the current catch phrase, having the "teeth" to implement their decisions. Such a task, in view of the parochialism existing in the industry, naturally proved beyond their powers. In fact, to paraphrase the report of the Committee under Lord Weir, which was appointed in 1925 to consider the question, five years of patient and capable effort were unavailing. Co-ordination was not achieved. Delay and procrastination were widespread and the policy of suasion could be written down as a failure. Some form of compulsion was therefore clearly necessary if essential re-organisation was to be effected. This was provided by the Electricity (Supply) Act, 1926, which established a Central Electricity Board, mainly to co-ordinate generation and to control primary transmission.

Nevertheless, for the last twenty years the position has continued anomalous. The "selected" stations, although operated in accordance with the orders of the Board, have remained the property of their original owners. The necessary new stations have also been built by the original authorities, the Board not having powers, save in exceptional cases, to undertake construction itself. Distribution, too, has remained in the hands of the original undertakings, although it was realised that some remedy for the many anomalies which existed in this field would have to be provided sooner or later. It is not surprising, therefore, that a Committee presided over by Lord McGowan in 1936 should have recommended a root and branch re-organisation which was to take the form of retaining the larger and more efficient undertakings and absorbing the smaller and less efficient bodies in them. It was intended that this re-organisation should be made compulsory as a step towards the public ownership of all the undertakings. Nothing formal was done to implement these recommendations, however, and their place has been taken by the more drastic proposals embodied in the Electricity Act, 1947.

It would be unfortunate, however, if this summary of past errors were to leave the impression that progress has lagged. On the contrary, since the early days of electricity supply in this country development has been steady; while during the last few years it has been rapid, as is shown by the fact that output has increased six-fold during the 21 years of the Central Electricity Board's existence.

* See ENGINEERING, vol. 124, page 531 (1927).
† *Ibid.*, vol. 142, page 15 (1936).

During the same period, too, the price per kilowatt-hour sold has decreased from 1·65*d.* to 1·08*d.*, in spite of the fact that the price of coal has risen by two and a half times. The industry, in fact, is both efficient and very prosperous; and there is no question of the new Authority being called upon to save a moribund concern or to apply remedies desperate enough to rescue any of the undertakings from bankruptcy. In fact, although a re-organisation, which had much to recommend it thirty years ago has only now been effected, the delay is not altogether to be regretted. Any agreement which would have been possible between municipal and private interests in 1919 would at best have been a compromise between the more and the less progressive elements in the industry, and would sooner or later have required amendment. Seven years later, when the Central Electricity Board came into existence, the soundness of the original proposals and the weakness of the opposition had both been emphasised. As a result, the standardisation of frequency, which would have been very difficult to achieve under any voluntary system, was carried out, and the electricity supply industry of the country was placed in a position which enabled it to withstand the shock of war and to play no small part in the attainment of victory. Much praise for this state of affairs is due to the personnel of the Electricity Commission and of the Central Electricity Board, as well as to the staffs of the various undertakings. It is fitting, therefore, that their achievements should be recorded before they are forgotten.

The British Electricity Authority, in fact, acquired a number of undertakings the condition of which is more prosperous than that of those concerns which have already come under the centralised control of the Coal Board or the British Transport Commission. On paper, the organisation of the authority, if at present a little top heavy, appears well designed to perform the task of developing "an efficient, co-ordinated and economical system of electricity supply for all parts of Great Britain." Contrary to the fears of some, the appointments that have been made to the higher ranks, both of the Authority itself and of the various Area Boards, show that the temptation to reward political supporters has generally been resisted. On the other hand, the experience already existing in the industry has been fully utilised. The determination of the chairman, Lord Citrine, to make the new organisation a success is obvious, and is well illustrated in a letter which he has addressed to those who now come under the control of the Authority. In this communication he stresses the magnitude of the task that has to be performed and points out how essential it is that all concerned should work together in comradeship and loyalty. He gives the assurance that the human factor will not be overlooked in the conduct of this great enterprise, and by so doing should do something to assuage the natural anxiety of those among the less senior engineers who fear that they may become redundant. To be capable of efficiency, however, is not the same thing as to attain it; and the hierarchy would be wise constantly to remind themselves of this fact. There are, in particular, two major legacies which will demand their closest attention: shortage of generating plant and poor quality of fuel. The first of these must cause anxiety for at least another five years, while no term can be set to the period before it will again be possible to purchase coal to specifications designed to ensure the maximum efficiency in the boiler house. Finance will also provide numerous teething troubles. One of these has been promptly tackled by the publication of an interim bulk supply tariff, details of which are given in a Note that appears on page 327.

On the whole, however, the future may be viewed with moderate optimism. Inherently, the organisation is sound and the problems with which it has to deal, though difficult, are not incapable of solution. The high-class technical and commercial experience of the industry are available in abundance, and if the liberal and far-sighted outlook with which operations have been begun can be maintained and political influences can be resisted, there is no reason why the future should not be even more successful than the past.

THE GAS INDUSTRY AND ITS FUTURE.

The announcement by Mr. George Gibson, the chairman of the North-Western Electricity Board, that "unfortunately, one of the first duties of the Board will be to increase the price of electricity for domestic use," must arouse considerable misgiving throughout the country; even though it appears at present that he was referring only to the area under his own supervision. It is to be expected, of course, that various plausible arguments will be put forward to show that the increase is not due in any way to the nationalisation of the industry, though it is improbable that the official apologists will have the courage (or the authorisation) to admit that the nationalisation of the coal mines and of transport are contributory causes. Most consumers will not need to be told anything so obvious—their own personal outgoings will have educated them in that respect, no doubt; but they may well be excused a certain uneasiness regarding the future of gas charges, when in due course the gas industry also passes out of private or municipal ownership into that of a State monopoly.

The arguments with which it is sought to justify the nationalisation of the fuel and power industries have been stated on many occasions, and are on record in various issues of *Hansard*; though it should not be forgotten that the gas industry differs from the others in one important particular, namely, the fact that nearly half of its employees are co-partners in it. A most useful compendium of facts and figures, entitled *The Gas Industry*, which was published a couple of months ago by the British Gas Council, mentions that some of the co-partnership schemes have been in operation for more than half a century and that 58 companies, having some 54,000 employees, now operate such schemes. The amount of capital held by the co-partners is of the order of 4,500,000*l.*, and the aggregate annual bonus paid to them is approximately 500,000*l.*, representing 5·44 per cent. of their wages. Under the terms of the Gas Bill, the trustees of co-partnership schemes would be required to wind them up and to distribute the assets; but some provision is made for the payment of compensation to the co-partners for the loss of their rights.

The structure of the industry is somewhat peculiar, partly because of the manner in which it has developed from small and independent local undertakings and partly because of its intimate association, in certain districts only, with other branches of industry, notably that of iron and steel. There is also the feature, not exemplified to the same extent in any other industry, of the great variety and value of the by-products, which have greatly influenced its economic aspects. In 1946, according to the British Gas Council's survey, there were 1,046 gas undertakings, of which 275 were owned by local authorities, 405 by statutory companies, and the remaining 366 by non-statutory companies. The statutory companies are either incorporated by special Acts of Parliament, or are limited-liability companies operating under statutory powers conferred by a Provisional Order (confirmed by Act of Parliament) or by a Special Order, made by the Minister of Fuel and Power and approved by both Houses of Parliament. Non-statutory companies are, normally, ordinary limited-liability companies, having no special statutory powers, and are only of small size in England and Wales, where they are obliged to become statutory if, in any one year, they have sold more than 30 million cub. ft. of gas. During 1946, the 1,046 undertakings made 418,146 million cub. ft. of gas, of which 36·4 per cent. was made by local authorities, 60·8 per cent. by statutory companies, and 2·8 per cent. by non-statutory companies. The total amount of gas supplied to consumers was considerably higher, however—rather more than 470,000 million cub. ft.—as nearly 52,000 million cub. ft. were purchased by the undertakings from coke-oven plants.

Approximately two-thirds of the gas sold is supplied to domestic consumers and the remainder for "industrial, commercial and miscellaneous purposes"; not a very positive indication, as a considerable proportion of the "commercial" consumption is likely to be indistinguishable from "domestic" consumption as regards purpose, except that it passes through the meters of commercial firms. However this rough estimate of distribution may be queried in points of detail, there is no question that the domestic load, in the country as a whole, is predominant; in fact, the British Gas Council point out, the ratio of meters to population is 1 to 3·7, indicating that nearly every house in the country has a supply of gas. The circumstance that the industry began, and for many years developed almost exclusively, as a source of domestic supply probably explains to a great extent why the expansion of industrial consumption has been more in recent years than the increase in domestic consumption—70 per cent. as against 44 per cent. since 1938. This is such a general comparison, however, that no really useful conclusion can be drawn from it without some examination of the effect upon consumption of the war-time expansion and dispersal of industry; the relative availability of gas and electric appliances to the small domestic consumer during the war years, and of the labour and materials necessary to connect them to the supply mains; the relative saturation of the domestic and industrial markets; and a number of other considerations which are not easy to evaluate.

It will be seen from the foregoing very broad outline of some of its special features that the gas industry differs materially from any of the previously nationalised industries and, for various physical reasons, is much less easy to carve satisfactorily into zones or regions. The problems thus entailed are further complicated by the existence of several "gas grids," among which the system of the Gas Light and Coke Company must be regarded as an outstanding example, although it was not originally designed as such. There are two other notable examples in Yorkshire, in which gasworks intended mainly for domestic supply are linked with local coke-oven plants. The significance that should attach to these plants as nuclei of administrative areas was emphasised recently by our contemporary, *The Gas World*, in an article which stressed that "It is of the utmost importance that these systems should not be torn asunder and divided between contiguous artificial regions . . . they should be retained as the initial foundation upon which the gas-distribution system of the country is built."

A great deal of co-ordination has taken place already in the industry, in part spontaneously and partly as the result of various inquiries and reports, but there has been some difference of opinion regarding the most suitable number of regional organisations. The Committee of Enquiry into the Gas Industry (otherwise known as the Heyworth Committee), which was appointed by the Minister of Fuel and Power, and reported in December, 1945, recommended the compulsory purchase of all existing undertakings by ten autonomous Regional Boards. A year later, when, at the request of the Minister, the British Gas Council investigated the matter—"including the question whether the Regions suggested in the Heyworth Report, or some alternative layout, would be the most appropriate and effective form of organisation"—they recommended that there should be 13 Regions. Now, according to the Bill, there are to be 12, designated as Areas, each with its own Area Board, responsible to the Minister, who will be advised by a Gas Council. A point which offers highly controversial possibilities is that the Area Boards and the Gas Council are to have power to manufacture plant and gas appliances, except for export: which suggests that the private manufacturers of such plant may not only have to rely on export business for their livelihood, but may be severely handicapped by losing some or even all of their home trade in unspecified branches of production. It cannot be said that the proposed organisation offers any real prospect that the future supply of gas will be materially better or any cheaper than the service that the country has had from the industry as constituted at present. Some additional linking-up may facilitate the maintenance of supplies in times of difficulty, but that could well be achieved without imposing the extra burdens of organisation and expense which appear to be inseparable in practice from schemes of nationalisation.

NOTES.

NATIONAL ELECTRICITY TARIFF.

THE British Electricity Authority have initiated a series of interim tariffs for the electricity which will be supplied by them in bulk to the fourteen Area Boards. These tariffs, which are estimated to produce an aggregate revenue sufficient to cover the Authority's expenditure on revenue account in respect of generation and main transmission, are made up of a fixed kilowatt charge in respect of each point of supply, and a running charge for each kilowatt-hour consumed. The running charge will, however, be subject to variation in accordance with the cost of fuel. In addition, both the fixed and the running charges will be subject to discounts or surcharges, in order to avoid abrupt changes in the cost of supplies to the individual Area Boards, compared with the costs which their predecessor undertakings might have incurred. To explain the reason for this discrimination, it may be recalled that under Section 13 of the Electricity (Supply) Act, 1926, the owners of selected stations were entitled to receive electricity from the Central Electricity Board at a price not exceeding the cost they would have incurred by generating for themselves. In a given area, the average price per kilowatt-hour supplied might therefore have been less or more than that determined by the grid tariffs, depending on the extent to which advantage was taken of this section. In consequence, the charges resulting from the introduction of a national tariff would have been favourable in some cases and the reverse in others. The new fixed kilowatt charge of 3*l.* 10*s.* per kilowatt and the running charge of 0·335*d.* per kilowatt hour will therefore be subject to surcharges varying from 3 to 10 per cent. in seven areas and discounts varying from 2 to 10 per cent. in five others. In the remaining two, neither a discount nor a surcharge will be imposed. In all areas the running charge will be increased or decreased by 0·0007*d.* per kilowatt-hour for each penny by which the fuel cost varies from 38*s.* per ton. The new tariffs differ from the previous Central Electricity Board tariffs in some respects. One fixed charge of 3*l.* 10*s.* per kilowatt replaces the sliding scale of 4*l.* to 3*l.* 8*s.* per kilowatt. For reasons of accountancy this will be calculated on the average maximum demand made during the year of account (April to March) and the preceding year between the hours of 7 a.m. and 7 p.m., instead of on the maximum demand during the winter months. There will no longer be any variation on account of changes in power factor or local rates. The former charge is considered unnecessary now that all undertakings have come under the same ownership, while the exact liability of the Authority and the Area Boards for rates has not yet been determined. The new running charge of 0·335*d.* per kilowatt-hour compares with 0·44*d.* under the grid tariff. As has already been explained, however, not all undertakings were being charged at the standard rate; and the new figure is an estimate of the average revenue that would have been received during the coming year had the Board continued in existence.

INTERNATIONAL ALTITUDE RECORD.

It has been announced by the Royal Aero Club that a de Havilland Vampire fighter aircraft has attained a height of 59,492 ft. Subject to confirmation by the Fédération Aéronautique Internationale, this raises the international height record for heavier-than-air machines by nearly 3,500 ft. As mentioned on page 160, *ante*, the previous record was established by the Italian, Lt.-Colonel Mario Pezzi, in 1938, when flying a Caproni 161 biplane. The Vampire used was entered jointly by the Ministry of Supply and the de Havilland Aircraft Company, Limited, Hatfield, Hertfordshire, and was piloted by the company's chief test pilot, Mr. John Cunningham, D.S.O., D.F.C. The entire flight from take-off to landing occupied only 47 minutes, and the pilot reported no deterioration in the handling characteristics at the altitudes reached. The flight is of unusual interest as it was made by a practical fighter and not by a machine designed solely for high flying at the expense of other qualities. Basically it is a standard Vampire fighter as delivered to the Royal Air Force and also to the Canadian, Swedish and Swiss Air Forces; it has an increased wing span, however, and is fitted with a de Havilland Ghost turbo-jet engine of the type being developed for use on the D.H. 106, a projected pure-jet transport machine.

SUPPLEMENTARY TRAINING FOR APPRENTICES.

Schemes for apprentice training have increased greatly in numbers during recent years and, in general, follow along well-defined lines; as a rule, there is a probationary period in which the intending apprentice has an opportunity to reveal his natural aptitudes, and then a course of training is laid down which will enable them to be developed. In most cases, either an apprentice school is maintained, to impart theoretical instruction up to the standard of some recognised qualifying examination, or arrangements are made for the apprentice to attend a local technical college. In a few instances, the employers offer the possibility of a subsidised university course to apprentices of particularly promising attainments. This is the general pattern of the numerous schemes now in operation, but it does not always meet the conditions that are found in districts where there are a number of firms too small to maintain self-contained schemes, and possibly engaged on a comparatively narrow range of products which, while requiring considerable skill on the part of the workpeople, are not sufficiently diversified to provide a comprehensive grounding in the fundamental engineering knowledge on which the specialised skill is based. To meet this need, the Enfield District Manufacturers' Association have introduced a scheme which appears to have distinct advantages. Through their Apprentices Sub-Committee, the Association will arrange for apprentices employed by such firms to obtain part of their training in other works where a greater variety of experience is obtainable; for example, a processing firm who wish to train an apprentice to become a maintenance engineer by giving him some experience of toolroom work, or the use of welding equipment, or the construction and upkeep of steam or electric plant, can arrange for him to be transferred for a period to another works for this purpose. He will continue to be paid by his original employer, who will retain certain rights of supervision over his employment. By this means, it is hoped to achieve a high standard of craft training and to meet the need for technicians capable of rising to executive Positions.

INTERNATIONAL CONFERENCE ON LARGE ELECTRIC SYSTEMS.

The next congress of the International Conference on Large Electric Systems (C.I.G.R.E.) will be held in Paris from Thursday, June 24, to Saturday, July 3, at the Fondation Berthelot, 28, rue Saint-Dominique, close to the Assemblée National. It may be recalled that this body was founded in March, 1921, under the ægis of the International Electrotechnical Commission. It is therefore not only one of the oldest of international electrotechnical organisations but is also the largest, having more than 1,000 permanent and 2,000 corresponding members. The programme of the forthcoming conference will follow the same lines as on previous occasions, except that there will be four instead of three sections. The first will deal with the generation, transformation and rupturing of current; the second with the construction, insulation and maintenance of overhead and underground lines; the third with the operation, protection and interconnection of networks; and the fourth with alternating- and direct-current transmission at extra high voltages. We understand that about 100 papers have already been prepared by engineers in various European and American countries and that others are expected. The proceedings will be conducted in the official languages, which are English, French and Russian, and facilities will be available whereby anyone conversant with one of these languages will profit fully by the work of the congress. At the close of the formal meetings, visits will be paid to installations of technical interest near Paris, while trips are also being organised to the hydro-electric schemes in the Massif Central, the Pyrénées and the Alps. The secretary of the British National Committee is Mr. R. A. McMahon, Thorncroft Manor, Dorking-road, Leatherhead, Surrey.

LABORATORY LIBERATION OF MESONS.

The United States Atomic Energy Commission have announced the liberation of mesons by Dr. Eugene Gardner and Dr. G. M. G. Lattes, working in the Radiation Laboratory of the University of California under the direction of Professor Ernest O. Lawrence. The big cyclotron completed at Berkeley in 1946 was not constructed merely to obtain increased yields of radioactive elements by known processes, but in the hope that it might reveal new processes that would help towards a more detailed understanding of nuclear structure. It was expected that, when bombarding energies of the order of 100 M.E.V. became available, sufficient energy might be communicated to nuclei to affect the meson forces and this expectation now receives dramatic confirmation. The particle, now generally known as the meson, was first postulated as a possible nuclear constituent by Yukawa in 1935 in the course of his theoretical investigations on nuclear forces. Such particles might carry a positive or a negative charge, equal in magnitude to the electronic charge. They would have masses several hundred times the mass of the electron and they would be unstable, having a mean life of the order of 10^{-7} sec. Previously, the sole evidence for the existence of such particles has come from the study of cosmic rays. The penetrating component of the cosmic radiation is capable of traversing a metre or more of lead. The particles concerned have energies exceeding 200 M.E.V. and are charged, since they are deviated by a magnetic field. Study of the ion density along the fast cosmic-ray tracks in the Wilson cloud chamber indicated that the charge on the particles was equal to that on the electron. Mass estimates, from photographs of tracks of the particles near the end of their range and subject to a magnetic field, which are difficult to obtain, have varied between 50 to 500 times the electron mass. Mesons, being unstable, must be generated as secondaries by the interaction between the primary cosmic radiation and the molecules of the atmosphere. Comparisons between the absorption of vertical and inclined penetrating rays in different materials have given the lifetime of the meson as between 2 and 4 microseconds. Now that mesons can be generated in the laboratory, it should be possible to ascertain their mass and mean life more accurately and to decide to what extent mesons of different mass occur. Final decisions may have to await the construction of even more powerful ion accelerators, since Professor Lawrence states that the 184-in. cyclotron proved barely capable of producing low-energy mesons. This brilliant achievement constitutes a major step forward in nuclear physics.

THE NORTH-EAST ENGINEERING BUREAU.

The North-East Engineering Bureau was established three years ago to continue, in effect, the kind of liaison work undertaken during the war by the Capacity Offices of the former Ministry of Production, and the annual report for the year ended December 31, 1947, indicates that its services in this respect have been appreciated. Some 125 firms are now members, and it is estimated that, since the establishment of the organisation, work to the value of more than 5,500,000*l.* has been placed as a result of the contacts made. As a development of the original scheme, a free technical advisory service has been arranged, to advise members on the planning and costing of production and on manufacturing methods. During the year, some 400 inquiries were dealt with, covering a wide range of products in the fields of light, medium and heavy engineering. The apprenticeship scheme which was initiated by the Board of Management in the previous year and is designed to train six apprentices and prepare them for the Higher National Certificate in Production Engineering, has progressed to the extent that five boys have been selected and have begun their training in the works of member firms. The office of the Bureau, of which Mr. J. F. Gibbons, A.M.I.Mech.E., is general manager, and Mr. J. E. Spoors, F.S.A.A., is secretary, is at the Guildhall, Newcastle-on-Tyne.

LETTERS TO THE EDITOR.

COUNCIL ELECTIONS IN PROFESSIONAL INSTITUTIONS.

To the Editor of Engineering.

Sir,—As one who conducts proportional-representation elections for bodies as various as the Institution of Naval Architects, the Church Assembly, trade unions and a political party, I am interested in the letters from Mr. Birkin and Mr. Ackermann, which appeared, respectively, on pages 256 and 280, *ante*.

None of the organisations using the method complains that it is cumbersome; on the contrary, when the change is first made they are usually surprised that it is so simple. Elections may take somewhat longer than by some other methods, but never much longer, and there is ample compensation for both scrutineers and members in seeing how nearly every vote has its due effect on the result. Of course, no method of voting can give a satisfactory council if nominations are unduly restricted, if the members are indifferent, or if the candidates are insufficiently well known to the electors; but "P.R."—proportional representation by the single transferable vote—does ensure that whatever votes are cast will be reflected accurately in the result.

Mr. Ackermann's plan of allowing members to vote for fewer candidates than the number to be elected will give a fairer result than insisting on the full number of crosses on the voting paper, but it is less reliable than P.R. and gives the voter less freedom of choice. Suppose, for instance, that there is a group of members who tend to vote for the same candidates—through community of interest or, perhaps, because they live in the same district. If that group is large, and if it has as many candidates as there are seats, it may secure all the seats; but if it scatters its votes over a larger number of candidates it may fail to elect any. Under P.R. it does not matter how many candidates there may be of a particular complexion; therefore, the voter can be allowed a wider choice. Under P.R., there is never any need to worry about what other voters may do; to say, for instance, that "So-and-so is bound to get in, so I won't waste one of my votes on him," and then to find, perhaps, that everyone has said that, and So-and-so has therefore failed. Everyone can vote quite honestly, in the confidence that his vote will be effective, no matter whether it is given in the first place to the most popular or the least popular candidate.

Yours faithfully,
Enid Lakeman,
Research Secretary.

The Proportional Representation Society,
82, Victoria-street, London, S.W.1.
March 22, 1948.

ENGINEERING UNITS OF FORCE.

To the Editor of Engineering.

Sir,—I entirely support Mr. Charles H. Helmer's recommendation, on page 280, *ante*, having used Stroud's notation since I first heard of it at the meeting of the British Association in Liverpool in 1923, when the paper was read by Professor Sir James Henderson and subsequently published in Engineering, vol. 116, page 409. This system does not necessarily abolish the slug, but makes it utterly unnecessary. It has two great advantages: firstly, that of making clear just when an answer is dimensionally wrong, which is an almost certain clue to a numerical error; and secondly, of enabling any units, or any mixture of units, to be used with certainty as to the conclusion. This latter is of special value when in the course of a day's work the thoughts of several schools of engineering may have to be drawn together and checked against the findings of the "purer" scientists.

Yours faithfully,
H. Wright Baker,
Professor of Mechanical Engineering.

College of Technology,
Manchester, 1.
March 24, 1948.

THE INSTITUTE OF METALS.

(*Continued from page* 305.)

Continuing our report of the recent annual general meeting of the Institute of Metals, we now deal with the last paper presented at the first session, held on the afternoon of Tuesday, March 16, and with the subsequent proceedings on the following day.

Striations: Metallographic Evidence of Slip.

The last paper taken on Tuesday afternoon dealt with "Striations: Metallographic Evidence of Slip," and was by Mr. D. McLean, of the National Physical Laboratory. The author stated that regular criss-cross "striations" had been observed under the microscope in lightly-deformed brass on sections electrolytically polished and suitably etched. It was found that the striations were sections through glide planes, which had slipped, and probably indicated non-uniform deformation on these planes. The failure to observe these markings previously had probably been due to the imperfections of mechanical polishing. In conclusion, Mr. McLean stated that an interesting point, not discussed in the paper, was the behaviour of the striations during recovery and recrystallisation, the question being whether they changed during recovery and disappeared, or whether they became sites for recrystallised nuclei. It was also interesting to note that sometimes in quenched specimens it was possible to find these markings throughout the body of the specimen, which seemed to show that slip had occurred during quenching.

The only speaker in the discussion, Mr. R. Eborall, said that the author's main conclusions had been well borne out by the more recent and slightly different paper by Burke and Barrett. The first occurrence of striations at the grain boundaries accorded well with the fact that, on subsequent annealing, the recrystallisation nuclei, in some cases at all events, formed preferentially at the grain boundaries, if the deformation had been small and appeared within the grains after higher degrees of deformation. Incidentally, Burke and Barrett had shown, in their paper, a structure in which recrystallisation nuclei were associated with striations. After a brief reply by Mr. McLean, the President adjourned the meeting until 10 a.m. on the following day.

When the members reassembled at the Institution of Civil Engineers, London, on the morning of Wednesday, March 17, for the second session of the meeting, Colonel P. G. J. Gueterbock, C.B., D.S.O., M.A., again occupied the chair.

Report of Council.

The first matter to be considered was the report of the Council for the year ended December 31, 1947. This showed that the members on the roll, on December 31 last, totalled 3,179, as compared with 2,980 on December 31, 1946, and 2,598 on December 31, 1945. The Council had to record with regret the deaths of Dr. J. W. Donaldson and Mr. H. H. A. Greer, J.P. (a Fellow of the Institute), both of whom had served on the Council. The Institute had also suffered the loss by death of Mr. N. A. Clark, Mr. T. A. E. Holdengarde, O.B.E., Mr. A. A. Jude, Mr. J. E. Openshaw, M.B.E., Mr. J. S. Glen Primrose, Mr. P. W. Rolleston, and nine other members. During the year 1947, 72 papers and addresses had been published, including those contributed to the "Symposium on Internal Stresses in Metals and Alloys." To deal with this record number of papers, the War-Time Emergency Fund, which had been raised for this purpose, had been drawn upon by the Publication Committee. The local sections had been very active during the year and had had good programmes of papers and discussions. The Birmingham local section now included Coventry and Wolverhampton in its area and would arrange meetings in these towns in the 1948-49 session. The name of the Swansea section had been changed to "South Wales local section," which more clearly indicated the area for which the section was responsible. The President had served as an honorary member of Council, on the Councils of the Iron and Steel Institute and the Institution of Metallurgists. The Joint Consultative Committee of the Iron and Steel Institute and the Institute of Metals had met several times to discuss problems of common interest. Much progress had also been made with library, educational and other activities in which the Institute participated jointly with other scientific societies.

Honorary Treasurer's Report.

The report prepared by the honorary treasurer, Mr. H. S. Tasker, and presented, in his absence, by Mr. W. A. C. Newman, indicated that the income for the financial year ended June 30, 1947, amounted to 8,972*l.* and the expenditure to 11,788*l.*, thus showing an excess of expenditure over income for the year of 2,816*l.* The year's deficit had been met by a transfer from the War-Time Emergency Fund, and the Council had decided that, as from July 1, 1947, among other things, the membership subscription must be increased. This step would enable the honorary treasurer to present a balanced budget for the year 1947-48. Attention might be drawn to the *Journal* account, which showed a change from 720*l.* excess of income over expenditure, in the previous year, to a deficit of 340*l.* in 1946-47. Against an increase in receipts of nearly 25 per cent., the cost of production had risen by upwards of 50 per cent. owing to substantial increases in costs of paper, blocks and wages in the printing industry.

After the presentation of the two above reports, the result of the election of officers for the 1948-49 session was read out by the secretary, and the President made a number of announcements, which included a statement regarding the presentation of the Institute Platinum Medal to Mr. R. C. Stanley, and the dates of forthcoming meetings. Particulars of these matters will be found on page 279, *ante*. The new President, Sir Arthur Smout, was then inducted and delivered his presidential address, which we reprinted in abridged form on page 285, *ante*. A vote of thanks to the President for his address brought the session to an end and the meeting was adjourned until 2.30 that afternoon, when Sir Arthur Smout re-occupied the chair.

Single- and Multi-Hole Die Extrusion.

The first paper taken on the afternoon of Wednesday, March 17, dealt with "The Effect of Single- and Multi-Hole Die Extrusion on the Properties of Extruded Aluminium-Alloy Bar." It was a communication on work done at the Armament Research Department, Metallurgical Branch, Woolwich, by Dr. L. Northcott, Mr. D. McLean and Dr. O. R. J. Lee, and was presented by Dr. Northcott. The authors stated that longitudinal streaks on the surface of aluminium-alloy components machined from extruded bar to specifications BA No. 35 and D.T.D. No. 423A had been found to be associated with erratic circumferential strength. The streaks had been found to be due to the flow structure originating in extrusion through multi-hole die plates and the principles would apply to alloys generally. To investigate the problem fully, billets of the two alloys had been extruded through die plates having one, two, three or four holes, all the multi-holes being symmetrically disposed about the centre. Transverse sections of bars extruded through multi-hole die plates showed a structure termed "radial flow," converging to that portion of the surface marked by the streak. This structure was absent from bars extruded through single-hole die plates. Segregation of particle constituents had been found near the periphery in the zone of radial flow, and, consequently, the circumferential tensile properties of multi-hole material were inferior to those of single-hole bar. Small-scale experiments with lead-bismuth composites and coloured plasticine had shown that the segregate originated from the axial zone of the billet. With a die plate having a single central hole, on the other hand, the axial segregate was confined to the axis of the single bar, where it was relatively harmless. The provision of a central hole in three- and four-hole die plates confined the segregate to the axis of the central bar, and this advantage had been confirmed by industrial trials.

The discussion was opened by Dr. R. Genders,

who stated that the authors' conclusions were not only in opposition, to some extent, to established knowledge on the subject, but even appeared to take the reader right back to the original erroneous view that the circumferential external defect in an extruded bar was a form of piping. It was well known that the type of flow which occurred in direct extrusion involved the cylindrical surface of the billet. This region turned inwards at the rear and, as extrusion proceeded, it followed a conical path towards the die. At some stage the outer skin of the billet could enter the die and form a defect in the extruded rod. There were well-known precautions to avoid trouble due to that cause. It appeared doubtful whether the authors' process of multiple extrusion, or any other simple method, would overcome the possible occurrence of surface defects. Reliance would still have to be placed on other precautionary methods, even if a central die-hole were adopted.

Dr. Northcott, in reply, said that they had studied previous work on the subject, but had not prepared a résumé of this as authors were repeatedly pressed to keep their papers short. One point which Dr. Genders had not mentioned was that the query which had led to the work had come from his own department during the war. Something had had to be done, and done quickly. The inspection organisation were becoming very worried; they were turning down tens of thousands of these components a week, although the Services needed them. When an investigation had been agreed upon, industry had been approached and had collaborated well. Investigators had been received in works and industrial managements had carried out any work which they had been requested to do. All concerned had appreciated that what was involved was not an ordinary type of extrusion defect. He was familiar with Dr. Genders's earlier work on the subject of extrusion defects on multi-hole dies, and the old type of extrusion defect, involving material from the outside of the billet turning inwards, was certainly not responsible for the trouble described. This fact had been thoroughly appreciated by the industry. Mr. D. McLean, who also replied, said that Dr. Genders was confusing his own results with theirs. Apparently, he was concerned with surface defects of oxide "strings," which got into a bar, but that had not been their trouble. What came to the surface and formed a detrimental feature of their bars were intermetallic inclusions. Microphotographs which they had taken had proved conclusively that the markings in question were intermetallic particles and not oxide.

(*To be continued.*)

CROMPTONIAN ASSOCIATION.—The annual re-union of the Cromptonian Association (formerly the Association of Old Cromptonians) will be held at the Café Royal, Regent-street, London, W.1, on Thursday, May 27.

RE-NUMBERING BRITISH RAILWAY LOCOMOTIVES.—The Railway Executive have decided to introduce a new system of numbering the locomotives taken over from the four main-line companies. This is to avoid using the same number on more than one engine. In general, the numbers of the former G.W.R. locomotives will remain unaltered (this railway was the only one to provide number plates on the sides of cabs and bunkers); 30,000 will be added to the numbers of former Southern Railway engines; 40,000 will be added to the numbers of former L.M.S. locomotives; and 60,000 will be added to former L.N.E.R. locomotives.

INSTITUTION OF PRODUCTION ENGINEERS.—Two medals have been awarded in respect of papers presented before the Institution of Production Engineers during the 1946-47 session. The medal for the best paper by a member has been awarded to Mr. W. H. Tait, for his paper, "Plain Sleeve Bearings, Materials and Design," presented to the London Section on October 24, 1946. The medal for the best paper by a non-member has been awarded to Mr. R. E. Wilson, for his paper, "The Relative Merits of Electrodeposited Nickel and Chromium," presented before the Yorkshire Section on April 7, 1947. The medals will be presented at a lecture meeting of the London Section of the Institution at the lecture hall, Royal Empire Society, Northumberland-avenue, London, W.C.2, at 7 p.m., on Thursday, April 8. The lecture on this occasion will be "Some Aspects of the Design and Production of Gunnery Control Gear," by Mr. S. Parker.

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Continued from page* 307.)

MORNING and afternoon sessions were held on the second day of the Spring Meeting of the Institution of Naval Architects, which was Thursday, March 18. In the morning, a paper on "Ship-Repairing and Shipyard Problems in the Invasion of Europe" was presented by Mr. A. J. Merrington, C.B.E., B.Sc., of the Royal Corps of Naval Constructors; and this was followed by a paper entitled "The Royal Navy and Nuclear Power," by Mr. R. J. Daniel, R.C.N.C. We give below summaries of these papers and abridged reports of the discussions.

SHIP REPAIRS IN THE INVASION OF EUROPE.

Mr. Merrington divided his paper into three parts: preparation for the Normandy assault and operations on the beaches; the advance through the French, Belgian and Netherlands ports into Germany; and work carried out in the liberated countries and Germany after the capitulations. Under the first heading, he described the repair ships and barges which were fitted out for the work on and near the beaches, and the several repair, maintenance and recovery units of trained officers and ratings which were organised. Despite the handicap of having to use, for the assault, ships and craft which had already seen considerable service in training, an availability of 97 to 99 per cent. was achieved on D-day. The total losses of craft in the assault were unexpectedly low, but the number damaged and the extent of the damage were greater than had been anticipated. The total number lost and damaged was about 290. Between June 19 and 22, a severe gale swept the beaches, and left 800 ships and craft stranded and damaged. Floating docks and a repair ship were used in the Mulberry harbour in Arromanches. During the advance, work was carried out at Dieppe, Le Havre, Boulogne, Calais, Ostend, Antwerp (which was relatively undamaged and provided considerable repair facilities), Flushing, etc. After the capitulation of Germany, there was much work to be done in connection with the surrender of the German fleet; the use of liberated and captured shipyards, dry docks, etc., for the benefit of the forces of liberation and occupation, and for continuing the war against Japan; and the survey of floating docks, ships of the ex-German fleet, etc., to facilitate Allied decisions on disposal. At Antwerp, Ghent, and elsewhere, a full programme of refits, repairs, conversions, and dry dockings was continued, but after the Japanese surrender there was a rapid reduction in British naval repairs. A total of 1,634 refits, repairs and dry dockings were completed at Antwerp from November, 1944, to September, 1945. In Germany after the capitulation, all ship-repair facilities in the British and United States zones were pooled, and all ships in these zones were considered pooled for repairs. by the end of September, 1945, in the British Zone, 1,040 ships had been repaired and 370 dry-docked, and 23 floating docks and 6 graving docks were in service. The Control Commission took over the main German commercial shipyards during the end of 1945 and the spring of 1946. During the nine months ended March, 1946, the Royal Navy had transferred many ships of the German fleet to the United States and Russia; they had repaired 2,575 ships, and dry docked 1,209.

Admiral Sir Harold Burrough, who opened the discussion, said that more than 4,300 ships and craft took part in the D-Day assault, and some 230 ships and major landing craft were billed to arrive daily at the beach-head. Events proved the organisation to be sound, though in the first month after D-Day, 65 per cent. of the total damage was caused by the weather. Dealing with the drive through the French, Belgian and Dutch ports into Germany, Sir Harold said that the main interest was focused in the Scheldt and in Antwerp. Once the Allies had held both banks of the Scheldt, the value of Antwerp as an unloading port was immense. The large ship-repair facilities at Antwerp were second in importance only to the discharging facilities. In February, 1945, he was deeply impressed by the orderly and expeditious manner in which the shipyard work was proceeding, in spite of the chilly Continental winter, heavy rocket and flying-bomb attacks, and the shortages of rations, coal and transport. Antwerp accomplished more than 800 refits and 200 dry-dockings under the arduous conditions of that winter. After the surrender, in May, 1945, his main objectives were to bring under Allied control the German naval and merchant fleets, their bases, dockyards and personnel; and by March, 1946, 24 major units and 300 minor units were transferred to the United States and Russia, without a single case of sabotage or scuttling. He had been pleased to receive representatives of British shipbuilders in September, 1945; their advice was of much value. It was necessary to keep certain German yards functioning on a reduced basis to deal with short-term commitments such as repairs to minesweepers. The shipyard labour in the main yards of the British zone, which was about 16,000 in June, 1945, rose to 22,000 by December of that year and then came down to about 15,800 by June, 1946. The plans and schemes had succeeded by virtue of splendid Allied co-operation; in particular, Admiral Burrough mentioned the great strength and support of the United States Navy.

Vice-Admiral W. Glassford (U.S. Navy), said that the American Navy could always be counted upon to collaborate and co-operate in every sense possible with the Royal Navy. He had arrived in London in July, 1944, as a member of a small planning group to work, with a similar planning group on the British side, on what should be done with Germany and the occupied countries. His principal duties, however, had to do with the European Advisory Council's Ship Repair Committee. Events were moving very fast, and there seemed still to be great scope for that sort of British and United States Naval co-operation.

Mr. A. C. Hardy referred particularly to the L.C.R.U. (Landing Craft Recovery Units) and the part played by the Government training schemes in providing facilities for training raw recruits as expert welders and shipwrights. Great success had attended their repair work on the beaches. Referring to his experiences in Denmark, he paid tribute to the work of the Ship Repair Committee formed there. The German fleet was extremely complicated and must have been very difficult to administer; there were extraordinary differences in the machinery. He considered that Mr. Merrington's paper, in the literature of shipping generally, was a most important "documentary" of the tremendous efforts made in the closing stages of World War II.

Mr. W. P. Christensen, in a written communication, which was read by Sir Amos Ayre, expressed the admiration with which shipbuilders learned of the perfect planning before the operation and of temporary ship repairs on the beaches under shelling and bombing, with very simple means, mainly electric welding plants and gas cutting; repairs were effected in a few hours which, in well-equipped shipyards, would have occupied days or weeks in the normal way. The capitulation, on May 5, 1945, had come so quickly that the demolition of the Danish shipyards, planned by the Germans, had materialised only to a very small extent. The shipyards were slightly damaged by sabotage from the resistance movement, but there were no stocks of materials. Thus the capacity of the shipyards was available to relieve the ship-repair load in the United Kingdom. The situation in Denmark at the liberation was complicated by the great number of ex-German ships in Danish waters. Thousands of refugees arrived in ships and barges and even in floating docks over the Baltic to Danish ports; but they had succeeded quickly in organising ship repairs and arranging for the supply of material. Besides the resources for ship repairs in the Danish shipyards, four ex-German floating docks were allocated for carrying out the repair programme. Three were put into serviceable condition, and repair shops were erected for use in association with them. With those facilities, they had calculated that they would be able to make available for Allied use within a short time 750,000 tons gross of non-operational ships lying in Danish waters. The organisation worked very satisfactorily. The capitulation of Japan in August, 1945, altered the conditions, but the Danish Ship Repair Committee

continued to function in connection with the repair of ex-German ships to be turned over to the Allies as prizes, the repair of German minesweepers, and also of Danish ships which had returned to Denmark.

Mr. H. S. Pengelly, formerly Fleet Constructor Officer on the staff of Admiral Sir James Somerville, Commander-in-Chief, Eastern Fleet, said that, in 1943, plans were prepared for landing on the Arakan coast early in 1944, in support of the armies operating against the Japanese. The meagre repair facilities on that widespread station, where distances were measured in thousands of miles, caused him great anxiety, The nearest capital-ship dock was at Durban; a dock at Bombay could just accommodate an undamaged aircraft carrier; Colombo and Calcutta could dock cruisers. If the operations had been undertaken and the landing forces had met determined resistance from the enemy, lack of repair facilities might have become a major problem. A necessary insurance for the protection of the British Empire appeared to be the provision of docks and machine shops at well-distributed strategic points, even if they were not economically employed in peace-time. Those facilities could not be provided at short notice in war, and fleet repair ships could meet only a small part of the requirements. Dealing with the paper, he said that the Landing Craft (Tank) which suffered broken backs during training were mainly the L.C.T. (4) type, which were specially designed with light scantlings for a calm-weather crossing of the English Channel and could not stand up to drying out on rough, uneven beaches; later they were stiffened, and many had made the ocean passage to India. Trials had shown that beach obstacles could generally be defeated by L.C.T. without serious damage, by driving the craft straight at the obstacles.

Mr. D. B. Kimber, who said that he had participated in nearly all the phases described in the paper, stressed the importance of uniformity in equipment. Certain of the British equipment had shortcomings; he had cast envious eyes particularly on the American trucks with welding sets, which would go anywhere and would get out of any sort of trouble. He would have liked also some of the long-boom cranes which the Americans used; they had a high lift and were able to go anywhere without becoming bogged, which could not be said of all the British equipment. The M.L.R.U. (Mobile Land Repair Units) were, perhaps, the most satisfactory repair units ever formed; they were mobile, well balanced in composition and equipment, and they were self-contained. The Landing Barges (Engineering) were an improvisation. Nothing better could be obtained at short notice, and they were better than nothing at all, but they got into a lot of trouble; they were swamped frequently, suffered bent shafts and propellers, and, generally speaking, they were nothing like so satisfactory as he imagined the converted landing craft tank Mark III to be, which was never in action in the European theatre. He felt that the function of the port repair barges had been misunderstood. Their function, as he conceived it, was not so much repair as first aid. They were not really equipped to take care of landing craft with broken backs, but they could and did get the water out of various craft, charge batteries, replace or straighten bent rudders, replace lost propellers, etc.; they repaired the craft that could be kept in service rather than the badly damaged craft. They also did a great deal in the recovery of beached craft.

The Scheldt shipbuilders and repairers had met well the rather stringent Admiralty requirements for full refits of ships up to destroyer and L.S.T. size. The effort which the German naval yard at Wilhelmshaven had put into the repair of the ex-German fleet for handing over to the Allies, he felt, had not been sufficiently publicised or realised. The ships had to be handed over in sea-going condition. Speaking from memory, he thought there were three cruisers, 16 destroyers, 80 E-boats, and literally hundreds of minesweepers, landing craft and smaller naval auxiliaries, representing about 8 per cent. of the ex-German fleet. A fair number of merchant ships were repaired also, but Hamburg had taken the major share of that burden. The majority of those ships and craft, particularly warships, were in very poor shape, particularly the machinery. Among some remarkable specimens of floating docks which were examined, there was one, at Hamburg, which was articulated in five sections, like five links of a bicycle chain; the links could be taken off or added one by one, to make the dock smaller or larger. At Kiel, there was a 6,000-ton dock, fully operational, which would be 70 years old next year. The pumps were belt-driven from an engine which he could only describe as the direct successor of the beam engine.

Mr. Merrington, replying to the discussion, praised the work of the naval planners, who could assess a problem and find a solution months or even years before an operation took place. The pooling of repairs in the British and United States zones in Germany had been of immense assistance, as had the Government schemes for training rather raw recruits from industry to form the landing-craft recovery units. Mr. Christensen had not reflected, in his contribution, a really full impression of the great help he had given to the Flag Officer, Denmark, and all the British naval staffs.

The President, in thanking Mr. Merrington for his paper, said that few people outside a very small circle knew what an enormous organisation was required to keep so many craft going, and he did not think that anything like sufficient credit had been given to those who had set up that organisation and had operated it. They had performed a great feat in getting very nearly 99 per cent. of the craft available for the actual invasion on D-Day; it was a great surprise at the Admiralty. After the invasion, the gale had done frightful damage, which had had to be repaired; and one would not say they had had to undertake more than they were prepared for. Expressing agreement with Mr. Pengelly concerning the provision of world-wide bases and repair facilities, the President said they would certainly be required in any future war.

The President then called on Mr. R. J. Daniel, R.C.N.C., to present his paper on "The Royal Navy and Nuclear Power."

The Royal Navy and Nuclear Power.

Mr. Daniel, who had visited Hiroshima and Nagasaki, and saw the Bikini atom bomb experiments, considered three aspects of his subject: passive defence against atomic weapons aimed at ships, nuclear energy as a source of power for ships, and the ship as an offensive unit armed with atomic weapons. He described the effects of an air-burst bomb and an underwater-burst bomb. In the former case, the light, heat and air blast were enormously greater than with a conventional T.N.T. bomb, but, in addition, and really quite incidentally to its main function of liberating a colossal amount of energy from the smallest possible detonating medium, the fission produced an intense radiation in the form of gamma rays and neutrons and a mass of radioactive fission products. In the case of an atom bomb burst under water, the four principal phenomena were: an underwater shock wave, which would have serious effects on a ship; air blast after the bubble broke the surface—only serious where the depth of burst below the surface was shallow; waves, which were not likely to have serious effects on major war vessels or merchantmen; and radioactive contamination of the target area. The author believed that the only reasonable approach to the problem of protecting ships from the effects of an atom bomb was to select a minimum distance, x yards, and to provide for protection against a bomb falling at least this distance from the ship. It was expected that this distance, which would depend largely on the weight, space and cost of insulation and shielding, would be less than the normal distance between ships operating in company. The superstructure of ships must be reduced to a minimum, and well rounded; all guns should be in turrets and fitted with remote power control; all radar antennæ, rangefinders, etc., should be designed to withstand the air blast; funnels should be stiffened and provided with baffles to prevent air blast reaching the boilers; all openings should be capable of being closed instantly; and the machinery should be designed and mounted to resist shock. He noted that already one type of vessel, the submarine, went a long way towards fulfilling these requirements. In his consideration of nuclear energy as a source of power for propulsion and auxiliaries, the author thought that there would have to be radical changes in the methods of winning that power, from those at present in view, if the system were to become of economic or strategic importance. He described the principle of a controlled reactor, or atomic pile, and pointed out that, although the heat produced could be utilised in a boiler for feeding steam turbines, the "coolant" (of the pile) would have considerable induced radioactivity. This would require bulky shielding of the turbines, etc., but it might be overcome by introducing a heat exchanger. In any case, the pile and cooling pipes must be shielded—about 800 tons of steel and concrete would be required for a plant of 150,000 shaft horse-power. Many other difficulties, for example, those associated with maintenance and repair, were apparent, but the particular advantage of the system would be in its suitability for underwater ships, since there would be no problems of combustion and fuels, and no oxygen would be required for combustion. The author described the section of his paper on the ship as an offensive unit, armed with atomic weapons, as "visionary." The cost of plutonium and other nuclear explosives would preclude the use of them on a scale comparable with that associated with T.N.T. in war. Controlled flight would be required. Naval architects would be concerned principally with the stowage, assembly, and arming of atomic weapons, and the provision of effective antennæ positions for all-round control.

Sir Stanley V. Goodall, who opened the discussion, said that, when he noted all that would have to be done if some degree of immunity were to be given to warships in the atomic age, he could not see how all the amenities which were now required in warships could be embodied if the ships were still to be effective fighting units. He was not so perturbed about the blast effect—it had always been difficult to sink a ship by blast; but the radioactive products, which were the result of nuclear fission, would necessitate intensive research by the Scientific Service at the Admiralty. The underwater effect was more serious. The paper had referred only to warships, and not to merchant ships. He dared not suggest that merchant ships would be made immune from attack by atomic bombs. There would be sitting shortly an International Conference on the Safety of Life at Sea; he did not know whether that Conference would take into account any of the lessons where they applied to merchant ships. Part of the paper, as the author had said, was somewhat visionary, but no doubt he had followed up his general survey by some investigations of what those visions actually meant in concrete facts; it was to be hoped that, some day, he would be permitted to tell the Institution the results of the more advanced investigations.

Professor E. N. da C. Andrade pointed out that there would be a great many problems other than those of nuclear physics to be considered; in particular, metallurgical problems, because once the construction of atomic engines began, it would not be practicable to employ the metals that would be employed now. The uranium rods in the pile had to be surrounded with metal to keep in the fission products and to prevent them from oxidising. The natural tendency was to use steel, because of its high melting temperature and its strength; but steel could not be used in the atomic age because, on account of the neutron absorption, the pile could not be made to work. At present, aluminium was used; but, at 300 deg. C., aluminium began to creep very slowly, and the rate increased quickly. Other metals, such as beryllium, might be used, but he did not think the metallurgist fancied it very much. Again, it was not known yet what would be the effect on metallurgical problems of bombardment by various particles; it might set up processes which would very seriously damage the metal. He supposed that one of the great advantages of the use of the atomic engine would be the greatly reduced weight of fuel to be carried. One ton of uranium would go a very long way.

Professor A. J. Sims commented that the naval constructor and, indeed, the designer of large merchant ships, must keep abreast of the possibilities of nuclear energy as a source of power for ship propulsion. The saving of fuel would be

welcome if it were not for the tremendous burden of shielding which would have to be carried; for large ships, there might be an overall saving. There was also the possibility that, with a given weight of fuel, it would be possible to provide much greater endurance; and there was also the twin advantage that, at long last, the submarine designer had the possibility of achieving the true submarine, namely, the submarine divorced from the necessity to use atmospheric oxygen. There were, however, some heavy items on the debit side of the account. Oil fuel needed very little attention at sea; on the other hand, a nuclear-power plant would require the utmost vigilance. Oil fuel could be stowed in places which it would be difficult to put to other useful purpose; nuclear power plant was less accommodating. There were considerable problems to be overcome in regard to safety. Naval architects could not neglect the consequences of a fractured pile, nor ignore the risks attendant on the reduction of the burden of shielding in order to obtain units of acceptable weight. Nuclear power plants for the propulsion of certain ships were likely to come, but there were many factors to be assessed before an ultimate decision could be reached. Everywhere, the fundamentals of warship design were being challenged.

Dr. S. Livingston Smith said that, a year ago, the physicists had talked of using atomic energy in the next two years; it was not a matter of two years, but maybe of 15 years. All that atomic power could do was to supply a source of relatively low-temperature heat, which had to be put into the working agent either directly or, as Mr. Daniel had suggested, by heat exchange. If the control reactor or atomic pile were used directly, it would be necessary to provide extensive shielding around the turbines and piping; if, on the other hand, the heat exchanger were to be used, he gathered from the paper that the upper limit of temperature in the whole plant would be of the order of 1,150 deg. C., because uranium melted at that temperature. If light alloys were used, the upper limit of the whole sequence of heat exchange would be something like 500 deg. to 600 deg. C., which would mean the use of enormous heat exchangers and turbines, or whatever was used. He agreed with the author that the total weight and space requirements for machinery and fuel would probably go up; the power per unit weight of working agent would be much less than had been customary in recent years. He felt that engineers must improve the equipment and prime movers they were already handling and deal with the many problems of to-day before they could make a lot of use of atomic energy.

Mr. D. E. J. Offord said that, from the military point of view, the atomic bomb did not mean the end of navies, or even of large fighting ships; but that did not mean that navies would remain unchanged—on the contrary, the advent of the atomic bomb had presented many new and unusual problems to warship designers. The important point was that the United States authorities did not consider those problems insoluble. Therefore, research on an adequate scale, and design, must go hand in hand, and neither could be unduly hastened if the quality of the finished product were not to suffer. For ship-construction items, the time which must necessarily elapse ftom the institution of any research project until its objective could reach full maturity in an actual ship would be at least ten years, and often longer. The need for intensive and high priority research into warship design problems, therefore, could not be too strongly emphasised. About half of the ships in the target array at Bikini were of merchant types. Ships of those types seemed to have been used as damage gauges, and, therefore, it was reasonable to suppose that some of them were quite close to the bomb at detonation. Some, but only a few, were sunk; thus the comforting conclusion could be drawn that a well-designed merchant ship would be sunk by an atomic bomb only if it exploded fairly close. At sea, therefore, such a ship was not very vulnerable, and it might be worth while to inquire whether that vulnerability might be reduced still further without undue interference with the ship's normal functions. It seemed that the upper works of merchant types at Bikini had suffered most, presumably from air blast; such items could possibly be improved in that respect without extra cost. The merchant-ship types were presumably of recent construction, and, therefore, would be expected to embrace a considerable amount of welding. The small number of sinkings indicated that that type of construction must have come out well under that very severe test; although the temperatures at Bikini were appreciably higher than those ruling when major strength failures had occurred in all-welded merchant ships.

The distance at which an atomic bomb would cause severe damage to a merchant ship was likely to be a multiple rather than a sub-multiple of her length. The explosive forces, therefore, would generally reach all parts of the structure at about the same time and would be of about equal intensities; the whole ship would be subjected, in fact, to a mighty squeezing action, and it seemed that, the better a ship was built by the ordinary accepted standards of good shipbuilding, the better would she survive the attack of an atomic bomb. It also seemed clear that the whole ship would be severely shaken by the suddenness of the impact, so that it was necessary to ensure that essential machinery and equipment could withstand such shocks. Little had been released concerning the progress of research in the use of atomic energy to drive ships, but it seemed unreasonable to expect a changeover in ship propulsion for several years at least. On board ship, the weight of the equipment was as important as its efficiency, and at present the amount of screening required for radiological safety made the prospect of atomic engines for ship work rather remote, except, possibly, for very large high-speed vessels. It might or might not be possible to avoid radiological screening—that was a matter for the nuclear physicist; but to an engineer, radioactivity was an unwanted by-product of the fission process and should be eliminated or put to good use.

Mr. E. C. B. Corlett, referring to the statement in the paper that navigation and station keeping radar aids must be developed, the idea being to con the ship entirely by radar, said that the radioactive condition from the atomic bomb was not only in gamma rays and neutrons, but also in β-particles, which ionised the air; it was quite probable that radar would be useless, in which case the ships would be blinded. On the application of nuclear power for propulsion, he said that, from a rough calculation, it seemed impossible to concentrate 50 knots to 55 knots in a submarine of some 8,000 tons displacement, using atomic power plant with an output of 100,000 kW. Sir John Cockcroft had stated that such a pile would require some 600 tons of steel and concrete shielding. He believed that, at a distance of 10 ft. from a normal pile, without shielding, a lethal dose of radiation was given in about two hours; so that, in an eight-hour day, anything between four and ten times the lethal dose would be administered. For a pile of 100,000 kW, a shield 8 ft. thick would give ample protection, and he thought that an 8-ft. thickness of concrete would not present an insuperable obstacle in a ship. For the protection of upper works from blasts and from radioactive particles and gamma radiation, he suggested that, as paint would ignite if there were an above-water blast, it seemed that the large-scale use of anodised aluminium was a distinct possibility. Two inches of anodised aluminium would cut gamma rays considerably, and its low modulus of elasticity rendered its shock-absorbing qualities very acceptable. A thickness of 3 to 4 in., in laminated plates of aluminium, in superstructures of rounded construction, if anodised and not painted, might offer a possible solution to the problem of protecting personnel.

Mr. D. B. Kimber felt that the difficulties of applying nuclear power to propulsion had not been over-emphasised; until the nuclear physicist could release energy without the attendant release of radioactivity, the possibility of using that source of power for ship propulsion appeared extremely dim. As to the design of ships for protection against atomic warfare, he had tried to test the reactions of the Naval Staff to a design in which some of the excrescences were eliminated; it had no funnels or bridge, and altogether it had looked a little "advanced." It had aroused enthusiasm; but they wanted a small bridge for use under certain conditions, and there must be openings so that the crew could let go the anchors, etc. Atomic weapons presented the naval architect with the greatest challenge to ingenuity he had ever had.

Mr. H. S. Pengelly said, regarding the passive defence of ships, that, provided the atom bomb exploded at some distance, x yards from the ship, the effects could be reduced considerably by strengthening and cleaning up superstructures, funnels, etc., reducing to a minimum the number of openings in the weather deck, providing decontamination arrangements, and by keeping the men under cover. In these days of radar, etc., it was less necessary for the seamen to be able to see, and in new designs there should be few exposed personnel. The author anticipated that x yards would be less than the normal distances kept by ships when operating in company at sea; that was reassuring, and suggested that an atom bomb would account for one ship only, or at most two, thus making the use of that weapon at current prices an expensive business for the attacker. A greater danger existed in fleet anchorages and dockyards, and it was difficult to see how they could be laid out so that important units were at least $2x$ yards apart, assuming x to be measured in hundreds. Convoys of merchant ships would need to be well spread out to avoid the loss of more than one or two ships by one atom bomb. As, in the past, counter measures had always been developed against new weapons, perhaps the atom bomb would be countered by some weapon or equipment which would ensure that the bomb was stopped or exploded at a distance of y yards from the target, where y was considerably greater than x.

Engineer Vice-Admiral Sir John Kingcome, commenting on the author's remark that the part of the paper dealing with the ship armed with atomic weapons was rather visionary, thought that this might apply also to the section dealing with nuclear energy as a source of power in the ship. The control of an atomic plant in a warship, where power was continually being altered, would not be simple. Again, though it was suggested that the reactor was compact, he doubted whether it would be a very compact item of ship's equipment. Professor Cockcroft had indicated that the land was the most likely place for the use of nuclear power. Big ships would probably follow, but the likelihood became less with smaller ships.

Mr. N. W. Honey considered that, the atom bomb being so expensive, it was unlikely to be used against individual ships, so that a fleet had a powerful defence weapon in dispersal and mobility, and must deploy so that each ship was at least twice the arbitrary distance x from every other ship. Thus, with the changes in design which the author had suggested, a fleet might be rendered comparatively proof against atomic attack. It was clear, however, that a comparatively small number of successful atom-bomb attacks could immobilise dockyards and bases. A "fleet train," on the lines of that used in the Pacific at the end of the war, would fulfil the requirements; but, in a modern fleet of depot and supply ships, each individual ship must be protected as far as possible against atomic weapons in the same way as future warships. Depot and supply ships would therefore become an integral part of any modern fleet, and naval constructors would have to give as much care and attention to their design as to that of other types.

Mr. Daniel, replying to Sir Stanley Goodall, said that, although blast might not sink a ship, it could immobilise certain essential features in a ship, rendering it difficult for the ship to move. He believed that the weight of the pile and heat exchangers in a ship propelled by nuclear power would be more than the weight of the fuel and engines in the ship with orthodox machinery, and he believed also that the length of machinery spaces would be greater. Dealing with the remarks concerning ships' structures and the likelihood of harbours being attacked by atomic weapons, he said that merchant ships sailing into those harbours would have to depend to a large extent on their own lifting appliances. The Americans had made a good job of producing strong funnels without guys.

(To be continued.)

CONSTRUCTION OF PROPELLER TEST BEDS AT HATFIELD.

THE development of aircraft and aircraft engines frequently provides structural engineers and contractors with unusual and interesting jobs. Buildings of a specialised nature are required for accommodating and testing aircraft. We have received particulars of an interesting example of such work from the Cement and Concrete Association, 52, Grosvenor-gardens, London, S.W.1. They refer to a structure for testing different combinations of aircraft engines and propellers, the structure having been completed recently for the de Havilland Aircraft Company, Limited, Hatfield, Hertfordshire. Fig. 1, on page 324, gives a general view of the structure nearly completed. Its shape in plan is that of a letter H; there are two reinforced-concrete tunnels, and a central building housing control equipment, workshops, etc. The tunnels are hexagonal in cross-section, approximately 30 ft. wide (normal to a pair of opposite sides), and 200 ft. in length. Each tunnel will accommodate propellers up to 21 ft. in diameter. At present, they will accept engines of 4,500 h.p., but it is hoped to render them suitable for propeller-turbine engines of 10,000 h.p. at a later date. The centre building is steel-framed and bricked.

The plant and instruments subsequently installed required that the structure should be built to within a comparatively fine margin of error for this type of work. The tolerance allowed in all internal dimensions of the tunnels was $\pm \frac{1}{4}$ in., and there were approximately 5,600 fixing bolts to be placed accurately. The plant installed in the building had already been drilled when it arrived at the site; nevertheless, only six bolts were found to be incorrectly placed. Each tunnel is supported on two rows of independent concrete blocks. There are transverse reinforced-concrete beams across the tops of the blocks; columns reaching up to the "knuckles" of the tunnel hexagon are supported by the ends of these beams, and the floor of the hexagon is cast on top of the middle portions of the beams. The whole of the structure at floor level, i.e., the beams, slab floor, and a low portion of the sloping walls, was cast on a sand bed 6 in. thick. This sand was subsequently removed by jets of water, immediately before removing the shuttering for the upper portion of the structure. The tunnels are therefore supported entirely on the two rows of blocks below the columns.

It will be clear from Fig. 2, on page 324, that the tunnels were constructed in stages, longitudinally. At each stage, the lower, outward-sloping walls were first cast as a series of strips, a shutter being used for each strip in turn. When casting the upper edge of each lower wall, a part of the upper wall was also cast, to provide an anchor for the shuttering of the upper wall. Shuttering for the outside of the lower walls (Fig. 2) consisted of light steel-angle frames with plywood panels. To ensure that it was located accurately, this shuttering was supported on rolled-steel joists which rested longitudinally on the transverse reinforced-concrete beams. Centering for the upper portion of the tunnels consisted of travelling false-work, as shown in Fig. 3, on page 324. A tower of tubular scaffolding was built to run on eight Decauville-type bogies, and support the panels. Two sets of narrow-gauge tracks were laid, and the travelling false-work was used for one stage of construction at a time.

Shuttering for the internal face of the lower walls and the external face of the upper walls consisted of light panels, 5 ft. high, held to the main centering by long bolts and nuts, as shown, for the upper walls, in Fig. 4, on page 324. The thickness of the wall was determined by pre-cast concrete spacer blocks between the inner and outer shuttering. These blocks also served several other purposes: they were provided with light rods projecting from the sides for supporting the main reinforcement, and each block had a hole through it for the shuttering bolt, and, subsequently, for fixing the plant installed in the tunnels. Construction of the two tunnels proceeded simultaneously, and in each case the walls and roof were built in stages from the middle towards each end. A concrete mixer was used at each end, and the concrete was conveyed by bucket skips on "Jubilee" track trolleys along the floor of the tunnel and hoisted to working level by a Neal crane (Fig. 2). Concreting was carried out in 4 ft. 6 in. lifts, and the concrete was thoroughly compacted by immersion vibrators. The main structure was of 1 : 2 : 4 mix, and the average of the results of 276 tests on sample cubes was 4,220 lb. per square inch. A completed reinforced-concrete tunnel is shown in Fig. 5, on page 324.

The consulting engineer for the reinforced-concrete work was Mr. H. Iorys Hughes, M.Eng., M.I.C.E., M.I.Struct.E., 66, Victoria-street, London, S.W.1, and the contractors for the reinforced-concrete work and the general work to the structures were Messrs. Holland & Hannen and Cubitts, Limited, 1, Queen Anne's-gate, London, S.W.1. The architects were Messrs. James M. Monro and Son, 11, Old Queen-street, London, S.W.1.

LABOUR NOTES.

THE special conference of trade-union executives, called by the General Council and held in London on Wednesday last week conditionally accepted a report by the General Council embodying its interpretation of the Government's White Paper on the subject of wages. It was not a unanimous vote. For acceptance, there were 5,421,000 card votes and against acceptance, 2,032,000 card votes, and the decision was qualified by five important reservations. These were: (1) That nothing should be allowed to interfere with free collective bargaining; (2) That wage claims based on increased output are justified; (3) That employees whose incomes are "below a reasonable standard of subsistence" should be given higher wages; (4) That it is in the national interest to give the under-manned industries wage rates that will attract employees; (5) That "differentials" which are "an essential element in the wages structure of many important industries" must be safeguarded.

What will happen now is difficult to say, as, to all intents and purposes, each union is free to make new, or to press existing, demands for wage increases. The unions which voted for acceptance of the General Council's report will, no doubt, refrain from embarrassing the Government by pressing existing wage claims or making new ones. That the unions which voted against acceptance of the report will act similarly is, however, extremely unlikely. Among these, it is understood, are several important craft unions including the Amalgamated Engineering Union—which is, of course, a unit of the Confederation of Shipbuilding and Engineering Unions—and the Electrical Trades Union. As each individual union is constitutionally free to do its own collective bargaining, the alignment indicated by the conference vote may not be found to be true in practice. Time must be left to tell the truth about that. Sir George Chester, of the Boot and Shoe Operatives Union, who moved the resolution to adopt the General Council's report, is apparently confident that matters will adjust themselves satisfactorily in the end. It was unthinkable, he said, that the Trade Union Movement could stand aside and ignore what the Government had asked them to do in "the unpreventable financial and economic circumstances of the time." The conference vote showed that the trade-union movement is still ready to respond to such appeals, but by no means wholeheartedly.

At a conference on Friday last week, the Association of Shipbuilding and Engineering Draughtsmen agreed to the employment in Britain of skilled draughtsmen from the Polish Resettlement Corps—provided British draughtsmen were not available. This reverses a decision arrived at by the Association a year ago.

Mr. Isaacs, the Minister of Labour and National Service, formally presented in the House of Commons on Monday last week, the Employment and Training Bill which seeks to make fresh provisions with respect to the functions of the Minister relating to unemployment; to provide for the establishment of a comprehensive juvenile employment service; and to consolidate, with amendments, certain enactments "relating to the matters aforesaid."

At February 17, the official index figure which measures changes in the average level of retail prices compared with the level (taken as 100) at June 17, 1947, was 106. The figure at January 13 was 104. Chief increases were in the prices of bacon and eggs.

By a narrow majority, delegates representing about 60,000 transport workers employed by municipalities outside London, accepted, on the advice of the executive of their union, the Transport and General Workers' Union, the wage increase of 7*s.* 6*d.* a week proposed by the National Joint Industrial Council for the industry. The original claim was for an increase of 1*l.* a week. The delegates also agreed to an increase in the number of standing passengers from five to eight. When the offer of 7*s.* 6*d.* a week was made, there were strong objections to it in several important provincial centres, and in one or two areas strikes took place. It will be recalled that an increase of 7*s.* 6*d.* a week was granted to London 'bus and tram men in February.

All grades of employees are affected by the provincial agreement which is effective as from the first full pay period after March 11. Juveniles get increases of 3*s.* (14 to 15 years), 4*s.* (16 to 17), and 4*s.* 6*d.* (18 to 20). The qualifying period for maximum rates is reduced from three years to 18 months.

In the course of a report on its work during the past six months, the General Council of the Trades Union Congress states that the number of joint production committees has fallen considerably since the war. "Sometimes," it continues, "the employers took the initiative in disbanding the committee because they had only formed one at the request of the Government and it infringed on managerial functions. In other cases, the shop stewards took the initiative, because they were not prepared to help increase the bosses' profits. In the view of the T.U.C. General Council, both these arguments are fallacious. If any profits are increased, the Chancellor of the Exchequer can be left to look after that. Our own standard of living is at stake."

When the coal-mining industry was nationalised at the beginning of last year, it was understood that there would be an experimental period during which the industry would have opportunities to find its feet. The National Union of Mineworkers has now, it is announced, undertaken an exhaustive survey in every area of the country with the object of ascertaining how matters are proceeding under the administration of the National Coal Board. The various areas have been called, among other questions, to state the number employed before the war and under nationalisation; if, with fewer officials, working would be smoother; and if there was any understaffing or overlapping. The inquiry will take place not only at pit level, but right through to the Divisional Board, including the labour, finance, production, marketing, administration, and welfare departments.

Official figures relating to the coal-mining industry state that in the week which ended on March 13, absenteeism among colliers at the coal face continued to increase; the percentage was 7·97 and it compared with 7·57 in the previous week and 11·22 in the week which ended on March 15, 1947.

The Civil Services Arbitration Tribunal issued an award last week on a claim for increased pay for superintendents of typists in Government Departments. An allowance of 40*l.* a year was awarded, but the increase is not to have effect until the considerations involved in the Government's White Paper on *Personal Incomes, Costs and Prices* cease to apply. According to Mr. L. C. White, the general secretary of the Civil Service Clerical Association, the decision confirmed the apprehensions of members that they are likely to be singled out for particularly unfavourable treatment.

A declaration of principle on the subject of joint management, adopted unanimously at the 15th Congress of the Confederation of Christian Trade Unions of Belgium, laid it down that rights of ownership do not imply that the owner of capital has complete freedom to use the assets of the undertaking in whatever way he chooses. The undertaking is a joint production unit, relying on the co-operation of employees, entrepreneurs (that is, the effective management of the undertaking), and owners of capital. The undertaking should, therefore, be managed in the interests of all. Management is not a monopoly belonging to capital; all members of the production unit are entitled to share it. Since the employees' right to participate in management is based on their contribution in the form of work, it is essential that the productivity of their work should be increased by a thorough-going reform and large-scale expansion of technical training and apprenticeship, and that occupational skill and employees' specialisation should be developed in every possible way. Employees have a right to share in the profits of the undertaking and to be kept informed of its economic and financial position.

Another declaration approved by the Congress defines the policy which the trade unions should, in their opinion, follow. As in the past, it is stated, the trade union is a permanent association of employees freely united under leaders of their own choice for the purpose of studying, promoting, and protecting their interests as operatives. Its essential role is still to uphold employees' rights, although it not only inquires into, but actively helps to create possibilities of social improvement. Every trade union, therefore, must accept its responsibility in organising the national economy, though without at any time forgetting that its first duty is to protect the interests of its members, so far as this is in conformity with the welfare of the whole community. Each employee must consider it his moral duty to belong to a free and permanent trade union, the constitution of which embodies the principles set out above.

Compulsory trade unionism, the declaration continues, is incompatible with the freedom and independence which are essential to genuine trade unionism; but trade-union members must do all in their power, by methods of persuasion, to awaken trade-union awareness among non-members.

TESTING AUTOMOBILES AND ENGINES.

Fig. 1.

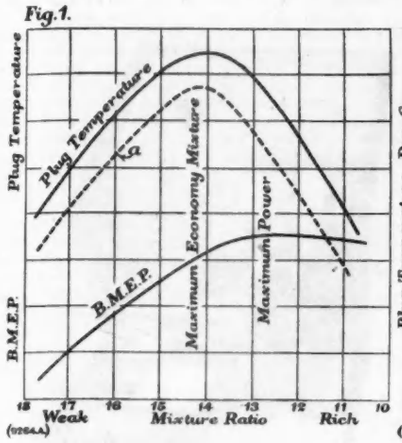


Fig. 2.

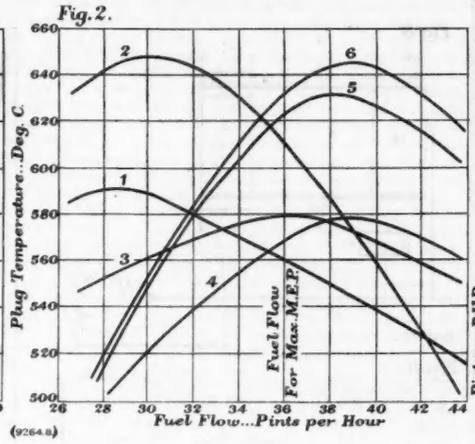


Fig. 3.

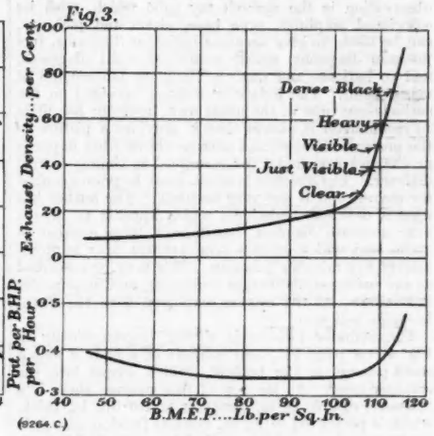


Fig. 4.

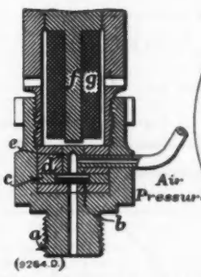


Fig. 5.

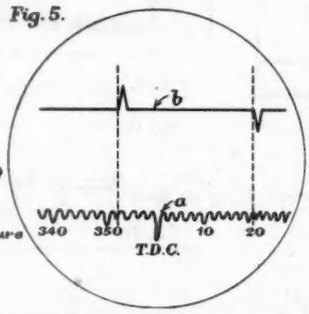


Fig. 6.

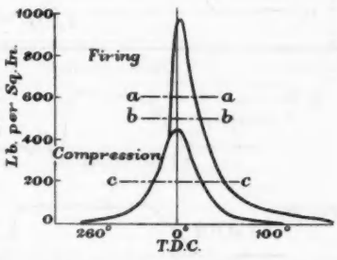
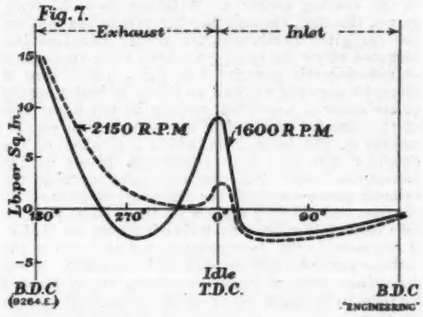


Fig. 7.



TESTING OF AUTOMOBILES AND AUTOMOBILE ENGINES.*

By E. B. STEAD, A.M.I.Mech.E.

THERE is to-day a marked trend towards more scientific methods in automobile testing. It may be argued that to use instruments other than the simplest is a waste of time, but in the author's opinion, the simple methods have failed to yield unambiguous results. A test which will remain peculiar to the petrol engine for as long as it uses the carburettor is the distribution test, but the established method of cutting out cylinders† has always been associated with uncertainty. Results seldom respond to changes in the expected manner, apparently because the temperature conditions in the manifolds and at the hot spot are altered by the cutting-out process, the gas flow is disturbed, and the friction of the shorted cylinder changed. A method apparently removing these doubts and which has been used by the author has been described by H. Rabezzana and S. Kalmar.‡ The method centres on the use of a sparking plug in which a thermocouple is incorporated in the centre electrode so that the temperature of this part can be measured while the engine is running. The requirements for such a distribution test are; a thermocouple plug for each cylinder which must be a matched set; compensating leads, to transfer the cold junction to a rotary, or other two-pole multi-point switch; and a high-resistance millivoltmeter calibrated for the temperature indicated by the plug couples. Before commencing the test it is important to ensure that the compression ratios of all cylinders are the same within close limits, and that reasonable equality of valve timing, particularly as regards the closing of the inlet valves, exists. A grade of petrol must be chosen which avoids all but slight detonation, while petrol with a high lead concentration should be avoided, lead distribution being a problem in itself. All the plugs should have roughly the same degree of external cooling and the ignition timing should be rendered manually adjustable.

The temperature indicated is that of the tip of the centre electrode, and this depends on the design of plug, the degree of cooling, and the combustion temperature. Plug design and cooling are equalised, but combustion temperature remains a variable, depending on compression ratio, charge efficiency, and mixture ratio. Compression ratios also have been equalised, so charge efficiency and mixture ratio are left to cause differences between the temperatures recorded from the various cylinders; and the author's experience with a considerably larger engine supports the findings of Rabezzana and Kalmar remarkably well. Fig. 1, shows what happens to plug temperature in any one cylinder when the engine is run at constant speed while the mixture ratio is varied from rich to lean. It will be noted that the temperature reaches a well defined peak at an air-fuel ratio of about 14 to 1, falling away as the mixture is enriched or weakened on either side of this point; this is the basis for determining the mixture strengths of the various cylinders when the engine is treated as a whole. Since charge efficiency also affects plug temperature, its effect can be assessed by throttling, and proceeding as before. The effect is shown by the curve lettered *a* in Fig. 1, from which it will be seen that the plug temperature reaches a peak at the same mixture ratio, but that the temperature reached is lower throughout the range. Hence, of the curves taken from a multi-cylinder engine for each plug, but in which the temperatures are plotted against fuel flow instead of mixture ratio, it can be said that the peaks occur at a mixture ratio of approximately 14 to 1, and that the total height is an indication of the charge efficiency. Fig. 2, shows a set of curves obtained from a six-cylinder engine thought to have poor distribution, owing to its inability to run weak on a "fish-hook" curve or "loop," and its generally poor fuel economy; the curves numbered 1 to 6 refer to the respective cylinders. Clearly there is considerable variation between cylinders, both in charge efficiency and mixture ratio and the engine is far from that ideal in which all the cylinders give the same temperature/petrol-flow curves. There does seem to be a method, therefore, of finding out all the facts about distribution; it remains to be seen whether by such means the ideal of cold carburation will be attained, or whether petrol injection will win the day.

The development testing of the compression-ignition type of engine has its own problems, not least of which is the fact that the maximum output at any speed is controlled by the tendency of the exhaust to get smoky. This tendency to smokiness is controlled mainly by volumetric efficiency and combustion efficiency. In engines which rely largely on port- or valve-derived swirl, these two efficiencies often run counter to each other, particularly when the speed range is high. Nothing shows up so clearly the deterioration in one or other of these efficiencies as the tendency for smoke to appear in the exhaust, an appearance which is not always accompanied by an increase in specific consumption. It has long been the practice of those concerned with this matter to describe the smoke as "just visible," "slight," or "moderate" and so on, but while the terms have meaning as used by one observer under the same conditions of light and humidity, others will apply the same terms differently. A smoke meter, therefore, is a most useful item of equipment, and the smoke density of engines turned out for road use should not exceed a definite standard.

During the recent war it was necessary to do quite a lot of testing after dark and as it was impossible to observe the exhaust, the author devised a smoke meter. The main feature of this instrument is that the sampling tube is vertical, the smoke enters at the top and in passing down to escape at the bottom, fills the tube. At the top of the tube an ordinary car side-lamp provides illumination down the tube on to a selenium cell of a light-meter reading in foot candles. The exhaust gas is bled from the engine silencer and is passed to the tube through a quick-acting valve and a distributor ring. The lamp is arranged so that it can be lifted off and the sample expelled by a small centrifugal fan situated in the bottom of the tube. The lamp is controlled by a rheostat and the current is supplied by a twelve-volt battery.

The length of tube is of great importance when consideration of standard exhaust density arises, as a long tube is sensitive to low densities and a short tube shows up variations in heavy densities. The author has found that a length of 18 in. gives results which can be most usefully interpreted with a reasonable sensitivity over the whole range from clear to black. In operation the light intensity is set to read 40 ft.-candles and the exhaust cock is turned on. The meter reading falls to a steady value and after this has been noted the cock is closed, the gases expelled from the tube and the process repeated. If the meter reading falls from the original 40 to, say, 30 ft.-candles, this drop of 10 is expressed as a density of 25 per cent. while a drop to 20 ft.-candles would be expressed as a density of 50 per cent. Fig. 3 shows how the smoke density, as measured on this instrument, varies with load on an actual direct-injection oil engine, and it will be noticed how fuel consumption increases with smoke density. The same thing happens if smoke appears, not as a result of setting the fuel pump at too high a delivery, but because the engine is out of tune. In this case a normal fuel delivery produces less power, and the lost power shows up unfailingly as smoke, the ill effects of which need not be stressed again.

Electronic instruments have come to the fore in recent years as a result of developments in radio. They have the ability to make possible the observation of movements or changes which take place so rapidly that lag between the occurrence and the observation

* Paper entitled "Notes on Test Methods and Some Instruments," read at a meeting of the Institution of Mechanical Engineers (Automobile Division), held in Coventry on February 10, 1948. Abridged.

† *Proc. Inst. A.E.*, vol. 30, page 639 (1936).

‡ *Automobile Engineer*, page 587 (1932).

TESTING AUTOMOBILES AND ENGINES.

or recording of it becomes of paramount importance, and must be eliminated if results are to be of any real value. The device most widely used for this kind of observation is the cathode-ray tube which, with its associated amplifier, time base, filters and pick-ups, can be made to give accurate indicator diagrams, fuel pressure diagrams, nozzle needle-valve lift diagrams, and to indicate and analyse vibratory movements of many kinds. The indicator diagram obtained on the cathode-ray tube in the usual way, however, has little to recommend it except that it provides a picture of the pressure changes, and perhaps shows what happens as changes are made, for example, in timing or fuel delivery. The diagram is small, must be photographed for record, and is not very accurate. The author has used a different technique, which appears to give a very accurate diagram, based on a large number of cycles and which gives a true average over approximately five minutes' running. This may be described as the balanced-diaphragm technique, and in principle it is similar to the system employed with the Farnborough indicator.

The cylinder pick-up is shown diagramatically in Fig. 4, on page 333, and consists of a body *a* with a small passage in the bottom, which screws into the cylinder head. At the top of this passage there is a magnetic disc *b*, $\frac{1}{8}$ in. diameter and 0·010 in. thick, which is permitted 0·002 in. vertical freedom in a hole in the spacing washer *c*. Weighing about 25 milligrams, this disc, the only moving part in the pick-up, has negligible inertia and can hardly introduce lag. Mounted above the spacing washer *c* is an upper plate of non-magnetic material *d* having a central core of magnetic material *e* drilled as shown to lead a supply of air under a controlled pressure to the upper side of the disc *b*. Above *d* is the pole *f* of an electromagnet *g*, the leads from which are taken to the amplifier and the vertical-deflection plates of the cathode-ray tube. The disc will move up when the cylinder pressure exceeds the controlled pressure above the disc, and will drop again when the cylinder pressure falls below this value. Each time it moves an E.M.F. is generated in the electromagnet and the spot on the cathode-ray tube will be deflected vertically. These deflections occur at known pressures, but it remains for them to be timed accurately in relation to the piston position.

For the timing of the deflections, the degree marker is used. This is a disc, driven at crankshaft speed, having slots cut in its periphery at intervals of 2 deg., but with deeper slots at 10 deg. and 90 deg. intervals. This is synchronised with the crankshaft, with one of the deeper 90-deg. slots at top dead centre, and the pole of another pick-up opposite the slot. As the disc rotates, the slots generate an E.M.F. in this pick-up coil, which produces a wave form on the screen of the cathode-ray tube, as shown at *a* in Fig. 5, on page 333. The sweep of the spot on the tube from left to right is controlled by a contact incorporated in the degree marker. In the instrument used by the author only one trace at a time can be shown on the tube, and it is necessary to switch from the trace showing the pressure deflections, indicated at *b* in Fig. 5, to the degree scale, after using sliding cursors to locate the deflections. The type of tube which permits two simultaneous traces to be shown would be superior for this particular purpose, although the switching is immediate since no integrating circuit is used.

Identification of top dead centre is difficult sometimes, so a third pick-up should be mounted over the flywheel, and either a deep slot formed in the rim of the wheel, or a pointer rotating with it, can be used to produce on another trace, or superimposed on either of the existing traces, a deflection at top dead centre. Accurate setting of top dead centre is best done on a compression diagram, the mean of that diagram being used as the gauge point. This procedure is sufficiently correct for all the purposes with which the author has had to deal. An actual diagram taken from a compression-ignition engine running at 2,000 r.p.m. is shown in Fig. 6, on page 333. The lines *aa*, *bb*, *cc*, represent some of the steps in the controlled pressure which was varied from over 1,000 lb. per square inch down to atmospheric pressure. No deflections occurred until the pressure was just below 1,000 lb. per square inch, and this determined accurately the maximum pressure. At very low pressures there may be more than two deflections, and some care is necessary in identifying them, particularly if the degree scale is spread out. The "light spring" results from the same engine are shown in Fig. 7, on page 333. Pressure is controlled as before, but a mercury manometer is used, and subatmospheric pressures require an exhauster pump. It will be noted that there is an appreciable build-up of pressure at the end of the exhaust stroke at 1,600 r.p.m., but not at 2,150 r.p.m. This is clearly a wave effect, the study of which can yield useful information for the determination of valve timing and sizes, and also the design of the exhaust manifold.

One of the most valuable uses of the electronic indicator is in the measurement and analysis of the torsional vibration of crankshafts and transmissions. The advantages compared with mechanical torsiographs are: virtually no limit to the frequency which can be measured with accuracy, and the ability to analyse a complex wave form by electrical filtering. The apparatus and many results obtained have been described by R. Stansfield, so only a brief description with some results obtained by the author will be given here. The pick-up consists of a coil or armature which is bolted through a flange to the front end of the crankshaft of the engine; that is, that end of the shaft remote from the node, which is usually at or near the flywheel. This coil rotates positively with the shaft and is subject, therefore, to the fluctuations of angular velocity experienced by that end of the shaft. Also driven by the shaft, but through slack dogs permitting several degrees of angular freedom, is a housing which surrounds the coil. This housing contains a permanent magnet, the magnetic flux of which cuts the coil. The leads from the coil are led through slip-rings to the amplifier of the indicator. Since it is permitted angular freedom to a limited extent, the housing does not follow the variations of angular velocity of the crankshaft and, in fact, rotates like a small flywheel with uniform velocity except when the dogs occasionally make contact. The space between the coil and the magnet is filled with grease, and this effectively damps out violent fluctuations, while the faces of the dogs are fitted with flat springs to absorb shock. When the engine is running on a crankshaft period, there is a coil which follows the angular displacement of the shaft, surrounded by a magnet rotating with uniform velocity. The relative velocity between the two parts generates an E.M.F. the value of which is proportional to the instantaneous velocity from which a wave form, representing the velocity of the vibrations, is obtained on the cathode-ray tube. This is of no practical use to the engineer, so the integrating circuit of the amplifier is used to convert velocity into displacement. The total height of the wave form thus obtained on the tube represents the total swing of the shaft. The time-base for this purpose usually is run at half engine speed so that the number of waves is twice the number occurring in one revolution, and the order number of the critical can be determined readily.

Unfortunately, the automobile class of engine, with its relatively light flywheel effect, seldom runs at steady speed from one revolution to the next, and for this reason, and also because of the occasional surging of the pick-up housing against the dog drive, the diagram on the screen jumps up and down. It is practically impossible to measure the height of the trace which, after suitable calibration, is the angular twist of the shaft. These fluctuations, however, occur at a low frequency compared with that to be investigated, and this fact enables a most ingenious method to be used for obtaining a steady trace. In this an electrical filter which can be tuned to pass only the required frequency of vibration is interposed between the pick-up and the amplifier. This filter works on the same principle as the tuning dials of a radio set and consists of chokes and condensers arranged so that the dials vary the capacity by a decade scale. The filter used by the author covers a wide range of frequency suitable for those vibrations likely to be encountered in automobile engines.

Road tests play an important part in the development of automobiles. A reliable presentation of the road performance of a vehicle is an essential requirement, whereas results often are coloured by the opinions of the tester. To obtain relisble results for purposes of comparison it becomes necessary either to average the results from a number of testers or to retain one tester on a particular job and to make frequent checks on the original condition. A further alternative is to combine the check method with the average of several drivers, but all three methods often leave room for doubt on some particular point. The most important aspects of performance include acceleration, braking,

Fig. 8.

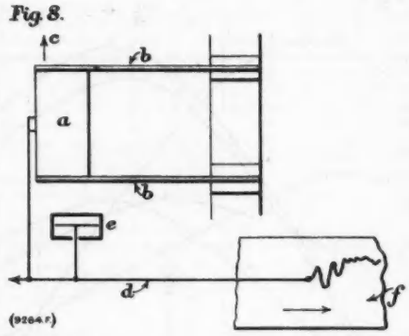


Fig. 10.

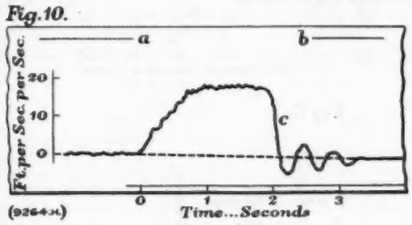


Fig. 11.

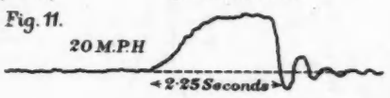


Fig. 12.

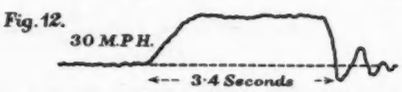


Fig. 13.

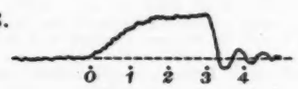
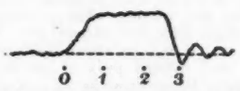


Fig. 14.



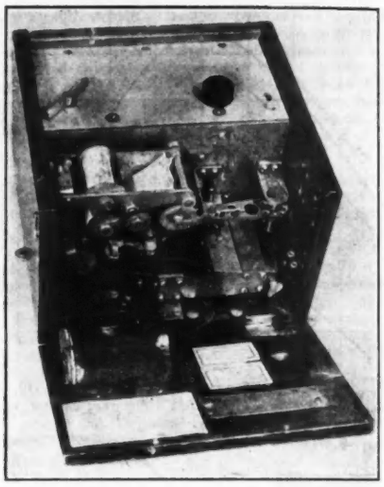


Fig. 9. Recording Accelerometer.

Fig. 15.

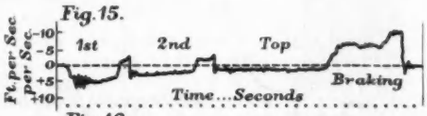
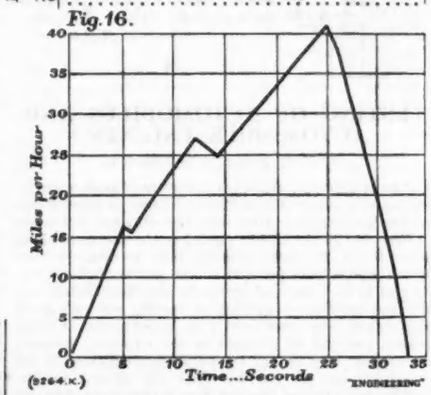


Fig. 16.



road holding, steering, suspension, and noise. Acceleration, braking and suspension lend themselves to instrumentation by the use of a recording accelerometer, the records from which leave no room for variables other than those on test or those due to weather conditions.

In brake testing, errors can be large because the distance varies as the square of the speed immediately before the stop. Errors of timing in the application of the brake also are considerable; furthermore, for comparative results a pedal pressure-gauge is necessary. Brake meters are useful as they cut out most of these sources of error, but they measure the maximum rate of retardation, and this may differ appreciably from the mean rate if the brakes are of the kind which build up their efficiency during the stop, or if there is a servo-system which introduces lag. The theory of instruments relying on a pendulum indicates that considerable errors are introduced by the tilt forward of the vehicle on its springs. If there is a total tilt of 6 in. in a wheelbase of 8 ft., probably an extreme case, in the 90 per cent. efficiency region, about 10 per cent. can be added to the meter reading, due to the resulting zero error. Perhaps this accounts for the efficiencies of 100 per cent. which have been recorded by some observers.

Acceleration tests are dependent on the accuracy of the speedometer, unless the time over measured distance from rest is taken. Calibration of the speedometer at steady speeds may give the wrong result owing to lag in the instrument under accelerating conditions. Given an accurate speedometer, the observer with the stop watch has quite a difficult job if the pauses due to gear changing are to be assessed accurately. Performance meters are excellent on gradients where the pull is steady, but appear to have too much lag to enable the accelerating pull to be measured, particularly in the lower gears. They tend to be difficult to read, except in smooth-running private cars.

In order to overcome these difficulties, the author has devised a recording accelerometer which records accelerations in any desired direction on a paper strip. A recording accelerometer was first described by the late Dr. Lanchester in connection with his classic experiments in 1909, and later by Wimperis, although in the latter case an indicating instrument appeared to have been used. These instruments, like the present day Tapley meter, were designed solely for the measurement of accelerations in the horizontal plane. The author's instrument is shown in diagrammatic form in Fig. 8, opposite, while the photograph reproduced in Fig. 9 shows the instrument as arranged for taking records in the horizontal plane. In Fig. 8, the mass *a* is supported on parallel plate springs *b* which are clamped to the instrument at one end. The mass is thus free to move against the resistance of the springs in one direction only, and for small movements this is in the line of the vehicle's motion. If the case of the instrument is accelerated in the direction of the arrow *c*, the mass *a* is subjected to this acceleration through the springs *b*, and the force exerted by the mass on the springs varies with the acceleration in direct proportion, while the springs also will deflect in proportion to the acceleration. The mass *a* is coupled to a suitable magnifying arm *d* and a record is taken on the moving ribbon *f*, the height of the trace being a measure of the acceleration to which the instrument is subjected.

When records have to be taken of accelerations which vary, the problem is less simple. The theory of the behaviour of such spring-supported mass systems has been given fully by W. K. Wilson for the case of a system subjected to vibrations of increasing frequency. As in all such systems, the dynamic-magnifier effect appears as the natural frequency of the element is approached, with the result that the scale departs a long way from the first-principle conditions given above. If the frequency of the vibration exceeds the natural frequency, the instrument changes its character and tends to record displacement, becoming a vibrograph. The accelerations met in vehicle work are not of a regular vibratory character, except in some cases in suspension work. The application of the brakes produces a sudden change from zero acceleration to a steady deceleration, and then back to zero again. The author has not been able to find any reference work on this aspect of such instruments, but has assumed that such changes of acceleration or transients are really a small part of a vibratory wave and can be treated as such. Such an assumption seems to be justified by results, but in order to overcome the difficulties the natural frequency of the element on its springs is as high as possible, to keep the dynamic magnifier out of the way of those transients normally met. For horizontal acceleration work, a frequency of some 10 per second has proved adequate, thus permitting measurement of a change of acceleration occurring in about $\frac{1}{20}$th sec.; for suspension work, however, at least double this frequency is desirable, depending on whether the instrument is to be placed on the floor of the vehicle or on a cushion of some kind. This demand for high frequency means that the springs are stiff and the movement of the mass small, so a large magnification is needed. The arm is made as light as possible relative to the mass and in order to achieve lightness combined with rigidity, the arm has been made from Bakelite.

To obtain freedom from solid friction for the arm a new method of recording on the paper strip was developed. A small wheel, with its axis along the arm, rolls on an inked ribbon, which is thus pressed lightly on the paper by the periphery of the wheel. A light touch produces a satisfactory trace, and friction is negligible. The inked ribbon is moved slowly past the marking zone, and a new surface is being presented continually to the wheel. To reduce solid friction further the arm is carried on knife-edge bearings.

Another essential for satisfactory working of this instrument is the damper, which is lettered *e* in Fig. 8. It is, in effect, an oil dashpot, a type of damper which appears to give damping increasing with the velocity of the piston. This is set to give critical damping of the mass-and-arm system at the natural frequency, and is therefore very mild in its influence at lower frequencies, but increasingly resistant to shock transients which are liable to be encountered.

The paper ribbon is moved by a spring motor, the speed of which can be controlled, while an accurate time base can be obtained by a second marker operated by a solenoid through a suitable contact clock. Alternatively this marker can be used to identify any particular place in the record, such as the point at which the brake pedal is depressed, or a certain speed is reached. A record of the deceleration obtained during a normal braking operation is shown in Fig. 10, opposite. The trace runs from left to right and the brake pedal is depressed at *a*. The rate of retardation increases over a period of nearly one second, up to a maximum of about 18 ft. per second per second. At *c* the vehicle comes to rest and the deceleration falls to zero, the wave effect being due to rocking on the springs; at *b* the foot was removed from the pedal. The diagram shows a degree of lag in the brake operation, and the average rate of retardation is less than the maximum. The average rate can be obtained by measuring the area of the figure which also is a measure of the speed of the vehicle at point *a*, before application of the brakes.

The brake records shown in Figs. 11 and 12, opposite, are from a fully-laden double-deck 'bus chassis, and show the difference in the diagrams obtained from braking at 20 m.p.h. and 30 m.p.h. In both cases there is a lag before the brakes reach their full efficiency, and, as a result, the mean rate of retardation is appreciably less than the maximum value. Some degree of lag appears to be a characteristic of all brakes that the author has tested. Those that have it least are generally of the kind that seem fierce and inclined to snatch, so a rectangular braking diagram is not ideal, although it represents maximum rate of retardation over the whole stop. The ability to measure the exact time of the stop will be of interest to those who prefer stopping times for assessing brake efficiency. The brake records shown in Figs. 13 and 14, opposite, illustrate how different servo-systems, on the same heavy vehicle, a transporter, can affect results. The system used in Fig. 13 had appreciable lag before the power arrived at the more remote cylinders, while that of Fig. 14 had a much reduced lag. While the maximum rate of retardation was 13 ft. per second per second, in each case, the mean rate was only 9 ft. per second per second in Fig. 13, and 11 ft. per second per second in Fig. 14, which is an appreciable difference in a vehicle of 35 tons weight.

In Fig. 15, opposite, the instrument is used for recording the acceleration performance of a car. It is only necessary to place the instrument on the floor of the car, select a level stretch of road, start the paper and the clock timer, accelerate to the desired speed, and then stop. The record then gives, by direct measurement, the time in each gear, the time required to change gear, and the maximum acceleration or pull in each gear, together with the total time taken to reach the speed shown by the speedometer. The brake test is performed to bring the record back to zero after the acceleration, rather than to test the brakes; a straight line drawn from end to end of the record is then the zero line, if the road were level. From the areas under each gear, the speed at each gear change can be calculated; the total accelerating area must equal the total retarding area, including the slowing down during gear changing, if results are accurate. The result of such work on the diagram can be the normal acceleration chart, shown in Fig. 16, which is obtained without reference to the speedometer or a stop watch. The waviness of the top diagram, due to road vibrations, can never be eliminated completely from such records. The severe waves at the beginning of the first gear acceleration and again at second gear are due to the fierceness of the clutch.

Calibration of the instrument is accomplished by running the paper and tilting the instrument over through 90 deg., for an acceleration of *g*, or 32 ft. per second per second, or, if this is too wide a scale for the paper, through 60 deg. for an acceleration of half *g*. The author uses, by selection of mass and springs, a scale of 32 mm. for *g* on brake tests, and 48 mm. for *g* on acceleration tests. This latter scale is adequate for accelerations of private cars, but is not really wide enough for a commercial vehicle. Nevertheless, the diagram yields the same valuable information about the time taken to change gear, etc. The response to tilt of the vehicle during braking is quite different from that of instruments incorporating a pendulum, in which the error is dependent on the tangent of the tilt angle and errors of as much as 10 per cent. are possible, with a softly sprung car, at high efficiencies. From the geometry of the author's instrument it will be evident that the increase in the reading due to tilt will be counteracted by the fact that the freedom of the element is now not in the line of the accelerating force, which is parallel to the road. The measured acceleration is dependent on the secant of the angle of tilt, and the error introduced amounts to only 1·8 per cent. in the example already given.

If the instrument is used with the mass free vertically, and mass and springs are chosen to give the highest natural frequency and the smallest scale, useful information about riding qualities can be obtained, such as periodicity at front and rear, effectiveness of shock absorbers, etc. If the instrument is set with the mass freedom across the vehicle, records can be taken of the centrifugal accelerations when cornering. Furthermore, with the mass freedom longitudinal, if the record is run for a short time on a level road to establish the zero, a run up a hill at constant speed will record the gradient; accelerating up a hill which is just within capacity for a given gear will give the tractive effort under sustained pulling conditions in that gear. The author has found this instrument of value in many tests which have to be undertaken in vehicle development work; it goes a long way towards removing guesswork from road tests.

NOTES ON NEW BOOKS.

The Machinists' and Draftsmen's Handbook. By A. M. WAGENER and H. R. ARTHUR. D. van Nostrand Company, Incorporated, 250, Fourth-avenue, New York, U.S.A. [Price 5·60 dols.]; and Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 28*s.* net.]

THIS book is an attempt to provide, in 650 pages, a work of reference for machinists and "draftsmen" which will contain most of the basic information required in their daily employment. Much of this information can be presented most conveniently in tabular form and is common to all the host of handbooks, year-books and pocket-books with which British engineers are so well supplied; in this case, two thirds of the book is occupied by such tables. Much of the remaining third is devoted to the solution of a selection of mechanical and mathematical problems of the more elementary type, presented with great lucidity and in considerable detail. Other subjects dealt with include geometrical construction, screw threads, heat treatment and the strength of materials. In a compilation of this type, in which authors are obliged by considerations of space to make a selection from among the enormous mass of material which might justifiably be included, their choice must be arbitrary and may be debatable. In this instance, selection has been made of subjects likely to be of use to those responsible for machining operations and engaged in the design and construction of jigs and tools. Power generation is not referred to; neither is the testing of materials. With regard to the suitability of the book for the British market it should be noted that neither Whitworth, B.S.F. nor B.S.P. screw threads are listed, and that the references to material specifications are all to the American and not to the British Standard codes.

The Application of Electro-Osmosis to Practical Problems in Foundations and Earthworks. By DR. L. CASAGRANDE. D.S.I.R. Building Research Technical Paper No. 30. H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 9*d.* net.]

WHEN two electrodes are placed in a saturated soil mass, with a direct-current supply across them, water is caused to flow from the positive to the negative electrode. This phenomenon, known as electro-osmosis, has two fundamental uses which are described in the paper. If the negative electrode is constructed in the form of a drainage well, water can be removed from a fine-grained soil more easily by this method than by any other known form of drainage. Secondly, by using such electrodes, the direction in which water is flowing in a soil mass can be reversed; thus, an excavation in which uplift or soil flow is likely to occur may be stabilised. Dr. L. Casagrande is the originator of this method of draining and stabilising soil. His paper is

in three sections: an account of model tests; a description of some large-scale tests and practical applications of osmosis in civil engineering works; and, finally, a discussion on the basic principles of the method. To civil engineers, the most interesting portion of the paper is that describing the practical applications of osmosis in the construction of an extensive railway cutting and bridge foundation near Salzgitter, the U-boat pen at Trondhjem, a tunnel cut in the Lerkendal valley and trench excavations at Auschwitz. In these cases—the first two of which were described in an article on page 121 of our 163rd volume (1947)—excavations which, without the use of osmosis, would have necessitated costly and elaborate engineering work, were accomplished, by its use, with comparative simplicity. The paper is written in simple terms, is well illustrated, and provides most interesting reading. Dr. Casagrande is working at present at the Building Research Station on the theoretical background of the subject, which, as the paper states, has been outstripped by the practical applications.

The Euston and Crewe Companion. By D. S. BARRIE. The Oakwood Press, "Tanglewood," South Godstone, Surrey. [Price 4*s.* 6*d.* net.]

As the title indicates, this booklet is intended to be studied on a journey from Euston to Crewe, for which purpose it is provided with folding diagrams, arranged to be pulled out clear of the text to facilitate reference while reading. The amount of information that the author has managed to compress into some 40 pages and his four folding sheets is remarkable, and his intimate connection with the line guarantees its authenticity, which makes it the more regrettable that the reduction necessary to keep the diagrams to a convenient size makes them rather difficult to read; some of the figures can hardly be read at all, and several unexplained abbreviations may puzzle the inexpert. The illustrations include some reproductions of considerable historical interest.

Locomotive Management. Cleaning, Driving, Maintenance. By JAS. T. HODGSON and CHAS. S. LAKE. Ninth edition. Revised by CHARLES E. LEE. The St. Margaret's Technical Press, Limited, 33, Tothill-street, Westminster, London, S.W.1. [Price 10*s.* net.]

IN a preface to the ninth edition of this book, which was first published 40 years ago, Mr. Charles E. Lee explains that he has reviewed the whole book and revised it wherever necessary, although, since many old locomotives are still in service, he was obliged to retain descriptions of features which have long since been superseded. The chapters dealing with railway regulations have been brought up to date, the principal data on some recent locomotives have been included, and there is a useful appendix on oil firing, which conforms with the latest practice. Owing to the destruction by fire of all the printing blocks used for the previous edition, the opportunity was taken of re-drawing the line illustrations in a standard style and of using new photographic illustrations. Would it not have been possible to include some of the excellent sectional perspective drawings of locomotives which were prepared in the chief mechanical engineer's department of the former L.M.S. Railway? Drivers and firemen, who are understood to be among the principal readers of the book, are not altogether familiar with machine-drawing conventions. Perhaps this will be practicable in the tenth edition, which will certainly be required, for the late authors' work remains unique.

Road Making and Road Using. By T. SALKIELD, M.I.C.E. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 12*s.* 6*d.* net.]

THIS is the third edition of Mr. Salkield's book and includes revisions to cover recent developments in highway engineering, including soil stabilisation. It contains a sound description of the principles of highway construction, including a discussion on drainage, a subject which receives too little attention today. There are, however, certain sections that might have been omitted, such, for instance, as that on the requirements of horse-drawn traffic; and it is possible to find some discrepancies in technical detail. Nevertheless, Mr. Salkield views his subject with a broad sociological and historical perspective, not often found among writers of technical books. For this reason, the book is one that can be recommended to students, surveyors and others wishing to obtain insight into the problems involved in road construction. By some oversight (or, perhaps, economy), the publisher's dust-jacket announces that the foreword is by Sir Henry Maybury, a former Director-General of Roads in the Ministry of Transport, who died rather more than five years ago. In fact, the foreword to the present edition is by Sir Charles Bressey.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

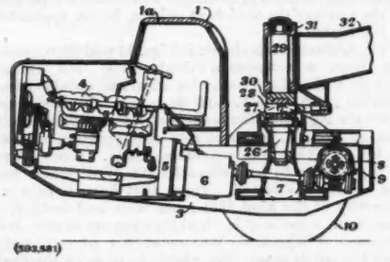
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is given after the abstract in each case, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AGRICULTURAL APPLIANCES.

593,581. Tractor-Drawn Vehicles. Blaw Knox, Limited, of London, and J. E. Conacher, of London. (3 *Figs.*) December 13, 1945.—The object of this invention is to couple a two-wheeled tractor to a two-wheeled trailer carrying an earth-moving device in such a way that the combination forms a four-wheeled vehicle, the trailer being able to pivot in both horizontal and vertical planes with respect to the tractor. This enables all four wheels to accommodate themselves readily to surface inequalities. The vehicle consists of a tractor generally indicated at 1, to which a trailer is coupled in a special manner. The tractor 1 includes a chassis 3 upon the forward end of which is mounted a power unit 4. A driver's cabin, indicated at 1*a*, is provided at the rear of the power unit. The power output from the unit 4 is transmitted through a clutch 5, change-speed gearbox 6, and transmission shaft 7 to differential gearing 8, the housing 9 of which is secured to the rear end of the chassis 3. The tractor 1 is provided with a single pair of road wheels 10 arranged one on each side of the chassis



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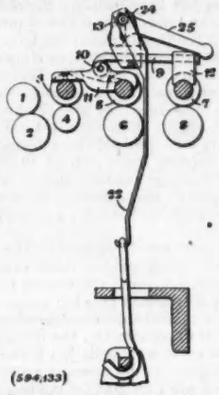
and situated in front of the differential housing 8, but sufficiently far behind the power unit 4 to ensure that the forward end of the tractor has a tendency to tilt downwards. A pintle 26 is fixed to and extends upwards from the chassis frame, the axis of this pintle intersecting at right-angles the axis of rotation of the road-wheel axles. The upper end 27 of the pintle is bored horizontally to form a bearing for a rotatable hinge pin 28 which extends in the direction of the length of the tractor 1. Above the pintle 26 there is a king-pin 29, the lower end of which is bifurcated, as indicated at 30, and secured to the projecting ends of the hinge pin 28. This arrangement allows the king-pin 29 to rock from side to side, that is to say, across the tractor 1, while being restrained against a rocking movement in the direction of the length of the tractor. The king-pin 29 supports a sleeve 31 which forms part of a rearwardly extending draught element 32, the rear end of which is fixed to a cross-tube. To each outer end of the cross-tube there is secured the forward end of a beam extending to the rear the two beams together with the cross-tube and draught element 32, constituting part of the framework of the trailer. The rear end of each beam is connected to and forms one of the supports for the axle shaft of the trailer. The space between the beams accommodates the earth-moving device. (*Sealed.*)

TEXTILE MACHINERY.

594,133. Roller-Weighting for Textile Machinery. Howard and Bullough, Limited, of Accrington, Lancashire, and W. A. Hunter, of Accrington, Lancashire. (3 *Figs.*). September 15, 1944.—The invention relates to a weighting device for the upper draughting rollers of textile machines, by which the weight distribution may be adjusted as between the several rollers in accordance with alterations made in the spacing of the rollers to suit variations in the staple-length of the fibres under treatment. The mechanism shown is intended for use in a draughting apparatus embodying four lines of draughting rollers of which the front, second and third rollers are in fixed spaced relationship while the back roller requires to be capable of adjustment towards or away from the third roller. The front rollers are indicated at 1, 2, the second line of rollers are indicated at 3, 4; the third line at 5, 6 and the back rollers at 7, 8. The weighting mechanism consists of a square-section bar 9 pivoted at its forward extremity 10 to a front saddle-member 11 spanning the upper rollers 3 and 5. Another saddle 12 for the upper back roller 7, is splined so as to be able to slide on the bar 9, and the weight-relieving attachment (which includes the bracket 13 and cam-lever 25) can also slide on the bar 9 between the pivot 10 and the back-roller saddle 12. It will be seen that any desired ratio of weight distribution may be achieved for the



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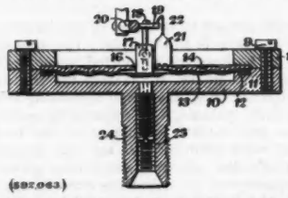
individual rollers by suitably adjusting the position of the weight-relieving attachment bracket 13 upon the bar 9, by sliding it either towards the front or the back. The weight-relieving attachment is of the known kind in which the weight-hook 22 is attached to a pin arranged for vertical sliding movement between the slotted cheeks 24 of a bearer bracket 13, the pin being operated by a cam-lever 25 arranged to bear against the upper face of the bearer bracket 13 in such a way that when the cam-lever 25 is manipulated the weight is alternatively raised or lowered. (*Accepted November 4, 1947.*)

MISCELLANEOUS.

592,063. Flexible Diaphragm. K.D.G. Instruments, Limited, of London, and A. Yeoell, of London. (3 *Figs.*), March 15, 1945.—The invention is a flexible diaphragm the effective stiffness of which is greater in one direction of deflection from a datum position than in the opposite direction. The device is used in compound indicating instruments for measuring both super- and sub-atmospheric pressures. A pressure-indicating capsule consists of a disc 10 having a rim 11, the face of which is provided with a groove holding a packing ring 12. The edge of a thin flexible diaphragm 13 rests on the packing ring and superimposed over this diaphragm is a thicker diaphragm 14. Both diaphragms are provided with circumferential corrugations which nest within one another, and the edges of the two diaphragms are clamped together against the sealing ring by a clamp ring 15 and set-screws 9. The inner diaphragm is continuous over its whole surface, while the outer one is provided with an aperture 16. An operating piece 17 extends



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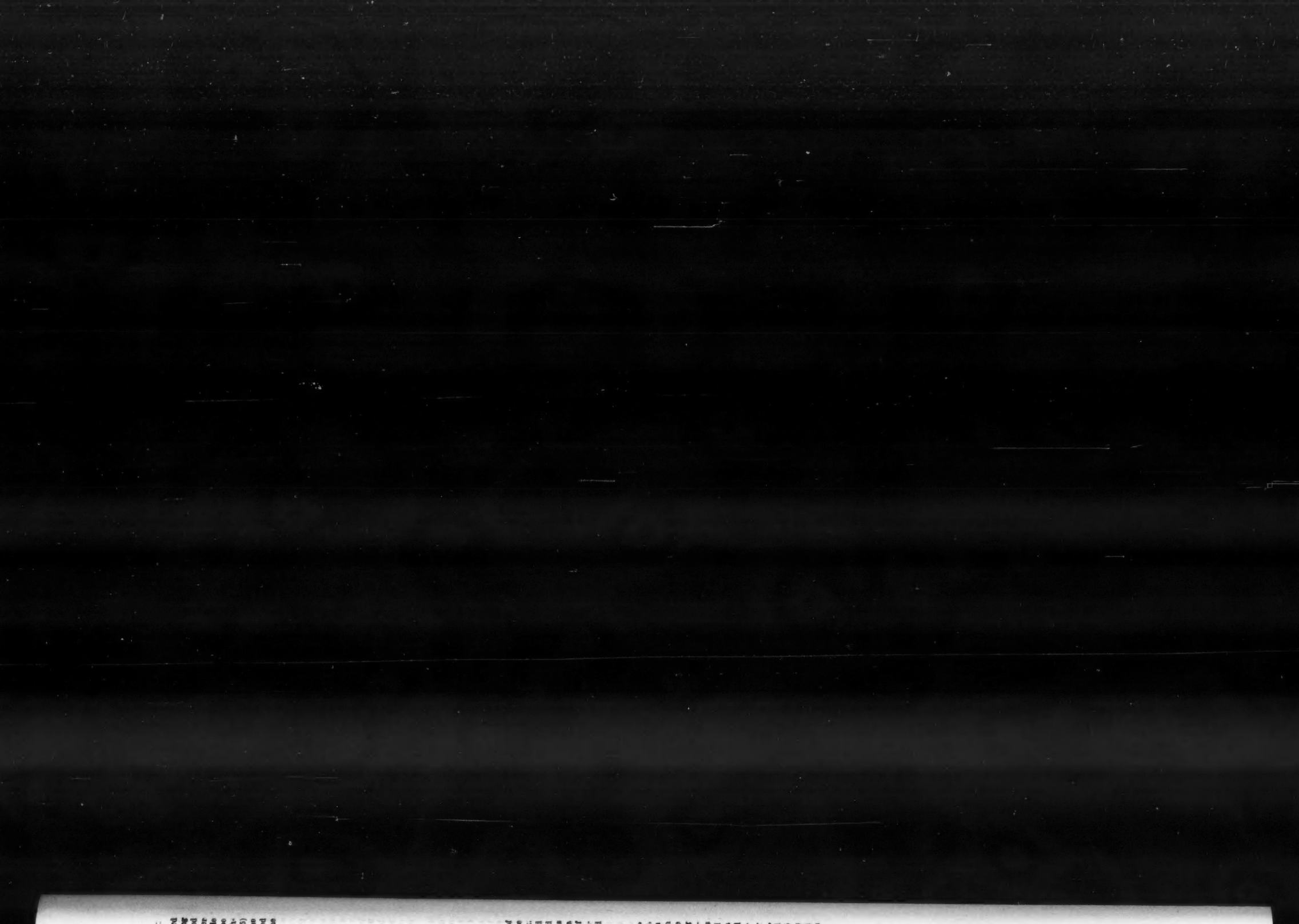
through the aperture and is provided with a hooked portion 18, which overlies a lever arm 19 on a rock-shaft 20, which forms part of the indicator transmission. The thicker diaphragm 14 is provided with a projecting portion 21 having a hooked end 22 overlying the same lever arm, but at a greater distance from the axis of rotation of the rockshaft. By suitably selecting the distance of the hooked portion 22 from the rockshaft, a predetermined rate of angular movement may be imparted to the rockshaft consequent upon an outward deflection of the diaphragms. The interior of the capsule communicates with the source of pressure through the passage 23 in the boss 24. Should the interior of the capsule be subjected to sub-atmospheric pressure, the thinner diaphragm only will be deflected inwardly and the hooked portion 18 alone will control the movement of the rockshaft. Since the hooked member is nearer the axis of rotation of the rockshaft, the movement of the shaft for a given deflection of the inner diaphragm will be greater than the movement of the shaft when the two diaphragms are deflected outwardly. With this arrangement, the indicating scale for the outward deflection will require to be more closely spaced than the scale for the inward deflection. (*Sealed.*)